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Connections between future time perspectives and self-regulated learning for mid-year engineering students: a multiple case study

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CONNECTIONS BETWEEN FUTURE TIME PERSPECTIVES AND SELF-REGULATED LEARNING FOR MID-YEAR ENGINEERING STUDENTS: A MULTIPLE CASE STUDY

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ABSTRACT

This dissertation presents multiple studies with the purpose of understanding the connections between undergraduate engineering students' motivations, specifically students' Future Time Perspectives (FTPs) and Self-Regulated Learning (SRL). FTP refers to the views students hold about the future and how their perceptions of current tasks are affected by these views. SRL connects the behaviors, metacognition, and motivation of students in their learning. The goals of this research project were to 1) qualitatively describe and document engineering students' SRL strategies, 2) examine interactions between engineering students' FTPs and SRL strategy use, and 3) explore goal-setting as a bridge between FTP and SRL.

In an exploratory qualitative study with mid-year industrial engineering students to examine the SRL strategies used before and after an SRL intervention, results showed that students intended to use more SRL strategies than they attempted. However, students self-reported using new SRL strategies from the intervention. Students in this population also completed a survey and a single interview about FTP and SRL. Results showed perceptions of instrumentality of coursework and skills as motivation for using SRL strategies, and a varied use of SRL strategies for students with different FTPs. Overall, three types of student FTP were seen: students with a single realistic view of the future, conflicting ideal and realistic future views, or open views of the future.

A sequential explanatory mixed methods study was conducted with mid-year students from multiple engineering majors. First a cluster analysis of survey results of FTP items compared to FTP interview responses was used for participant selection. Then a multiple case study was conducted with data collected through surveys, journal entries, course performance, and two interviews. Results showed that students with a well-defined FTP self-regulated in the present based on their varied perceptions of instrumentality for their present tasks and evaluated and adapted their SRL strategies based on grades. Students with conflicting perceptions of the future used a high level of SRL in courses related to both conflicting future paths or related to their short-term goals. Students with open views had high SRL in most of their courses due to a high perception of instrumentality for their present courses. Implications for practice include use of a context-based SRL intervention to teach effective learning strategies, a shift of key general education courses to earlier in the engineering curriculum, and utilization of career-focused problems to support student FTP development and stress the importance of course content in future engineering careers.

DEDICATION

This work is dedicated to my family. I want to first thank my husband, Kenny, for going through the hardest part of this program with me. To my mom, dad, sister, and brother, thank you for being available, for the amazing support, and for your love during this process.

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Most importantly, I thank God for the many blessings I have that allowed me to complete this degree, along with my caring family, helpful friends, and supportive colleagues.

TABLE OF CONTENTS

Table of Contents (Continued)

Page

Table of Contents (Continued)

Page

Table of Contents (Continued)

Table of Contents (Continued)

Table of Contents (Continued)

Page

Table of Contents (Continued)

Page

LIST OF TABLES

List of Tables (Continued)

Table Page

LIST OF FIGURES

List of Figures (Continued)

List of Figures (Continued)

List of Figures (Continued)

List of Figures (Continued)

CHAPTER ONE

1. Introduction

1.1 Background

With the call for training and graduating one million undergraduate STEM majors to fill jobs of the future[1], supporting undergraduate engineers during key years of development and equipping them with the skills they need to be successful in the field are vital. Understanding students' motivations and how different aspects of motivation impact student study behavior and regulation may have an impact on the development of higher education and teaching. By investigating student motivation and learning and building the literature, practitioners will be better able to understand their students, motivate them in their courses, and support them in their self-regulation.

Studies show connections between motivation (Future Time Perspective (FTP)) and learning processes (Self-Regulated Learning (SRL))[2–5]. These studies are primarily quantitative and often focus on a single or related aspect of SRL, such as academic performance, self-efficacy, goal orientation, intrinsic motivation, and extrinsic motivation[6–11]. Additionally, most studies analyzing relationships between FTP and SRL focus on metacognitive strategies, one aspect of the three-dimensional learning construct[12]. For example, Tabachnick et al.[13] used path analysis to show a positive predictive relationship of distant future goals on less distant sub-goals and the use of metacognitive strategies. While some literature shows the connection between students' motivations and self-regulation, scholars have criticized that the literature needs strengthening. More work focusing on additional pieces of SRL is needed: varying methodologies (particularly qualitative methods), domain-specific research, and socio-cultural contexts are necessary to complete the picture of students' FTP, self-regulation, and how the pieces fit together.

Connecting FTP and SRL has the potential to help practitioners understand a more diverse population of students. Underserved populations of students may have less developed views of the future, and an underdeveloped FTP affects the creation of sub-goals, and thus SRL strategy use[4]. Additionally, understanding the development of student SRL strategies is important for practitioners as SRL is associated with higher academic achievement levels[14] and connects students' skill to their will[15,16]. Engineering students need to develop strategies to study successfully and be able to apply learned material in future courses and careers. Studies have shown that knowledge about SRL strategies, such as the cognitive strategies of elaborating and rehearsing[17], are not enough to make an impact, and that motivation to utilize the strategies must also be present[18,19]. By studying the connection between the FTP and SRL of students with varying FTPs, practitioners can better understand students' motivation and strategy use.

1.2 Theory

1.2.1 Future Time Perspective

The first development of theory related to students and their perceptions of the future considered future views as being important for human motivation and behavioral choices[20,21]. Stemming from the work of Nuttin and Lens[22,23], time perspective has blossomed in the education and psychology literature as an important component of undergraduate student motivation. Time perspective rests in the affective domain and has been shown to positively affect student achievement, choices, and persistence[24].

Husman and Lens defined *Future Time Perspective* (FTP), a motivational theory relating future goals and present actions, as "the degree to which and the way in which the chronological future is integrated into the present life-space of an individual through motivational goal-setting processes"[25] (p. 114); Simons et al. defined FTP succinctly as "the present anticipation of future goals"[24] (p. 122). In both definitions, FTP combines views of the future, goal-setting, and their impact on present actions. FTP constructs may be either domain-general (primarily stable characteristics developed since birth[26]), domain-specific (e.g. engineering), or context-specific (e.g. in a particular course); these constructs relate how students' FTP traits affect their perception and behavior in current tasks[27,28]. According to Hilpert et al.[26], context-specific constructs have a greater impact on learning and are the bridge between the current task and student's domain-general FTP.

The majority of literature about FTP which relates to present tasks take the "top down" approach. This view often relates domain-general FTP traits to some mediator, such as goal orientation or self-efficacy, in relation to an outcome, such as knowledge building strategies or academic performance. Additionally, domain-specific FTP may affect context-specific phenomena, such as the connection between an engineering student's domain-specific FTP traits and SRL behaviors in a computer science course, based on an assessment of student learning profiles[29]. This top-down model is shown in Figure 1.1 (adapted from Husman et al.[30]). This dissertation focuses on the domain-specific FTP of students within engineering, context-specific tasks (courses), and the SRL behaviors that occur and their relation to the students' FTPs.

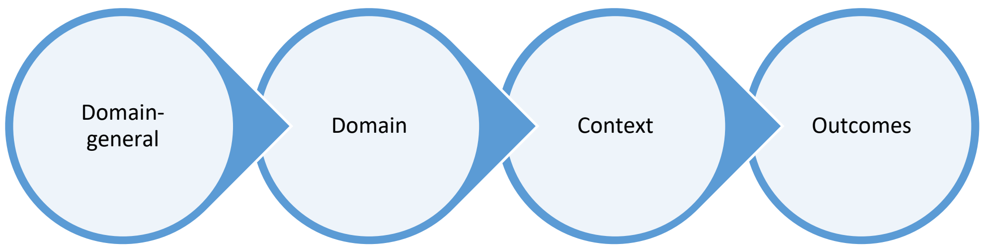


Figure 1.1: A "top down" approach to analyzing the connections between FTP and an outcome.

1.2.1.1 Domain- and Context-specific FTP

The focus of this work is three domain- and context-specific constructs. First, domain-specific (engineering) pieces of student's *Perceptions of the Future* are: extension, time attitude, and time orientation. *Extension* refers to a feature of the distance and path of goals projected *into* the future. An extended (long, deep) FTP features motivational goals which reach far into the future, thereby supporting short and long term activities. Additionally, a person with an extended FTP will develop clearer, more anticipated goals, and this person is considered to have a strong view of the impact of the *Present on the Future* (PoF). The longer a person's *extension*, the more important future goals will feel as they will appear closer to the present[25]. Within this extension, people may have a "more or less positive or negative outlook or attitude concerning his or her future"[25] (p.

115), or a *time attitude*. A person's *time orientation*, or the focus of their "habitual time space"[25] (p. 115), can be past-, present-, or future-focused, and people naturally have a tendency toward one of the three.

Perceived Instrumentality (PI) (also perceptions of instrumentality), or the importance of current tasks to the future and achieving future goals[25,31,32] is a context-specific aspect of FTP. PI is considered a context-specific variation of *connectedness,* the "general feeling of connectedness to and planfulness about the future"[25] (p. 116), while students who have strong *career connectedness,* the domain-specific variety of connectedness, are seen to more readily identify the importance of current tasks to future goals (i.e. have a stronger PI for related activities or learning in the present)[25,26,30]. If a task is perceived to be directly related to a student's future goal, such as understanding content within a mathematics course for a future engineering position, it is considered *endogenous*. In contrast, if a task is considered something to be overcome to move forward to a future goal, such as a high grade in a course to get into medical school, the PI is *exogenous*[33]. A high PI combined with a positive time attitude has been shown to positively affect school performance and overall motivation[34]. Additionally, longer FTPs, referring to *extension,* have been seen to have a significantly positive relationship with the task value or PI of study behavior to reach future goals[35].

The third domain-specific FTP construct considered in this work, effects of the *Future on the Present* (FoP), relates how a student's view of the future impacts or relates to a current task. Similarly, effects of the *Present on Future* (PoF) refers to the extent to which a student's task directly relates to their future goal creation This is distinguished from PI, which relates to the importance a student places on a task in terms of achieving a future goal[36]. Together, F, PI, PoF, and FoP create a feedback loop that characterizes a student's FTP within engineering[36].

1.2.1.2 The Motivation and Attitudes in Engineering Survey

More recently, FTP has been used to understand the connection between student motivation, the future goals of students, and the effects of students' future goals on short-term goal-setting and actions[25,37]. The Motivation and Attitudes in Engineering (MAE) survey was developed to assess the motivations and attitudes of undergraduate engineering students[36,38–40]. Items were developed based on theory[25,41,42] and adapted from validated survey instruments[43–45]. The section of the MAE survey used in this dissertation focuses on *Expectancy*, stemming from Expectancy Value Theory (EVT)[46], and FTP items. Expectancy describes the "beliefs about how one will do on different tasks or activities"[46] (p. 110), including outcome and efficacy expectations. The FTP items on the MAE survey include domain-general, domain-specific, and context-specific items including Value, Connectedness, Perception of the Future, Future on Present, and Perceived Instrumentality constructs. *Value* (or valence), the "anticipated subjective value"[47] (p. 567) that a person sets on distal future goals, is a domain-general FTP construct. Responses to MAE FTP and E survey items are indicated on 7-point Likert-type scales with anchors "0-Strongly Disagree" and "6-Strongly Agree." The survey is attached in Appendix J.

1.2.1.3 FTP Cones

Previous work has characterized students according to their FTP, which provides a model (see Figure 1.2) for researching FTP both qualitatively and quantitatively[36]. Research based on this work characterized students according to their FTP[36,48–51]. An Interpretative Phenomenological Analysis (IPA) of data collected through interviews with second- and third-year engineering students (N=9) focused on the students' FTP[36] facilitated the development of a visualization for the FTP of engineering undergraduates as different shapes of ice cream cones (see Table 1.1). A phenomenography[36,49,50] built on the IPA study and discovered characteristics related to engineering student FTPs.

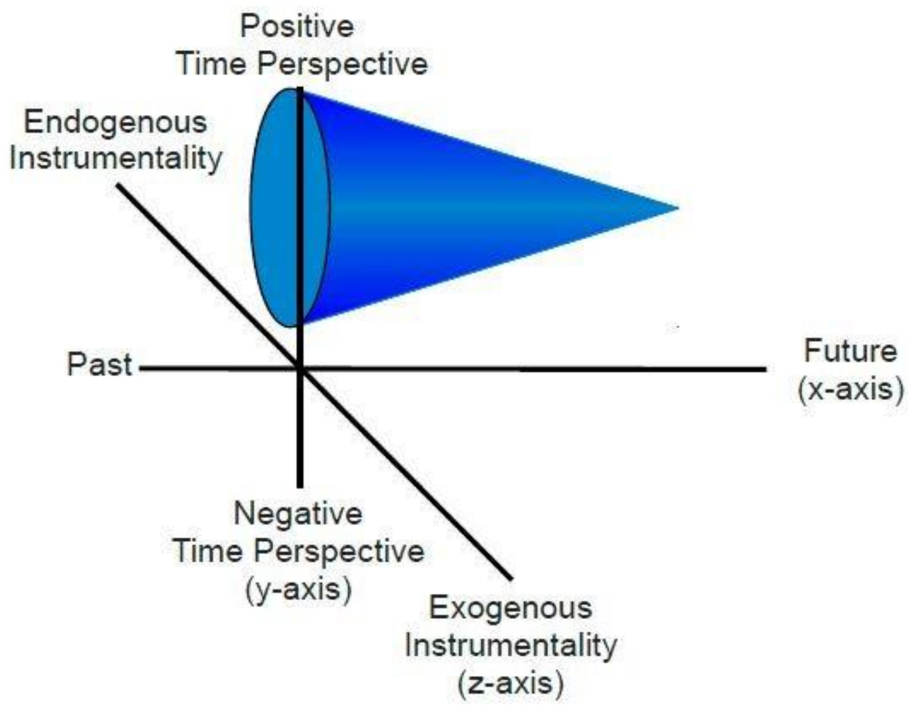
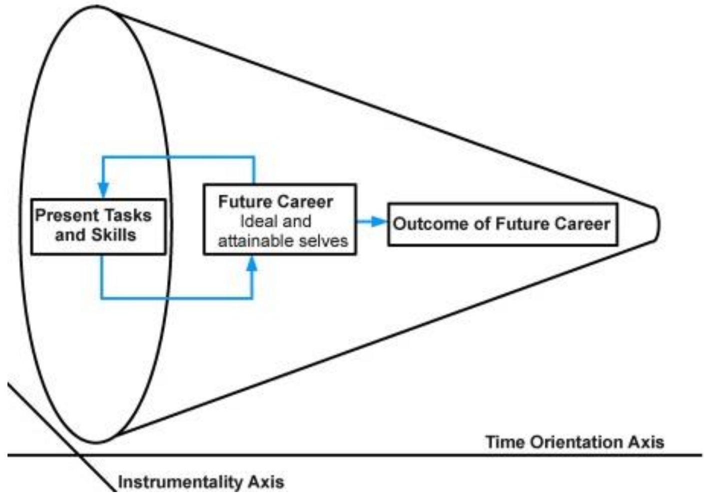
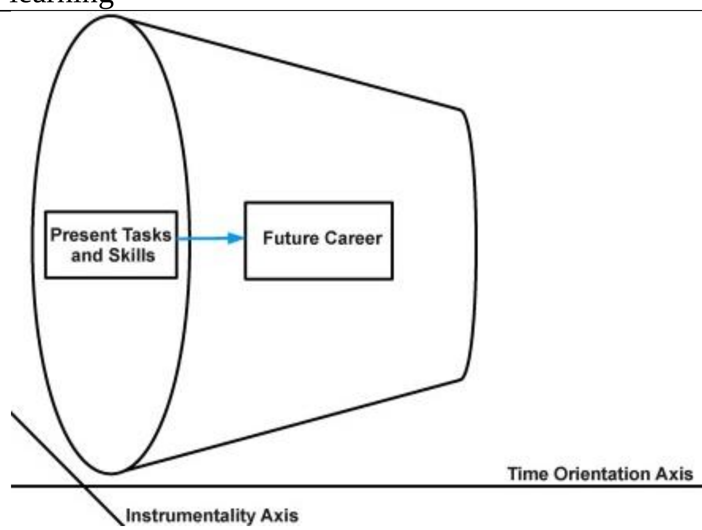


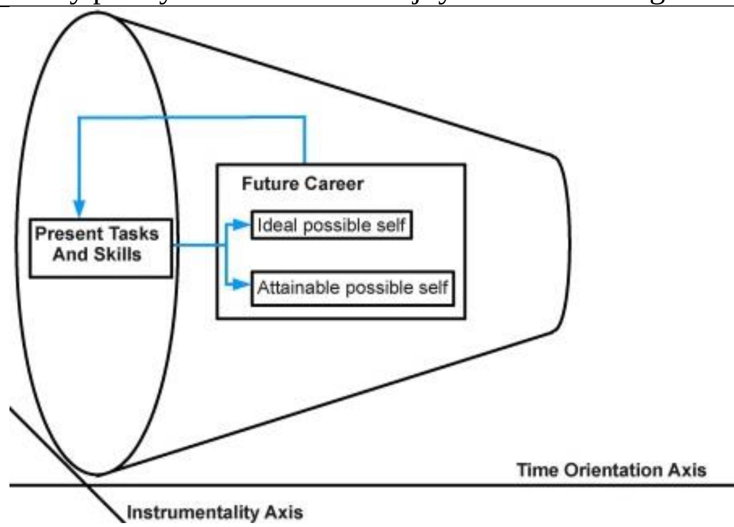
Figure 1.2: A FTP cone model, depicting an x-axis which provides a range of time orientation (from past to future), y-axis providing negative to positive time perspective, and z-axis with exogenous to endogenous instrumentality perceptions.

The different cone shapes are defined along three major FTP constructs: time orientation (focus ranging from the past to the future) on a horizontal axis, Perceptions of the Future (positive or negative) on the vertical axis, and PI (exogenous to endogenous) on the orthogonal horizontal axis. Three cone shapes have emerged from prior work [36,52]: “Sugar Cone,” “Waffle Cone,” and “Cake Cone.” “Sugar Cone” students generally have high scores on all FTP constructs, with a single ideal and realistic future career, and can make direct connections from their future to current tasks (and vice versa). “Waffle Cone” students have high FoP scores, lower PI scores, and conflicting views of ideal and realistic future careers. “Cake Cone” students have generally lower FTP values with a very open view of the future, limiting the connections they make between the future to the present and influence of present actions on their future goals because they have no clear expression of a desired future career [36]. More details about each of the three cones in this model can be seen in Table 1.1. Quantitative, qualitative, and mixed methods studies utilizing the MAE survey and interview data have confirmed the hypothesized cone-types[36,39,40] and the overall group FTP scores for Future, Future on Present, and Perceived Instrumentality scores are below[39]:

Group 1 (Sugar): high F, PI, and FoP scores
Group 2 (Waffle): lower F, PI, FoP scores than Group 1 and a low PI score overall
Group 3 (Cake): lower future scores, high PI scores, and overall low FoP scores

Table 1.1: Comparison of students' FTP characteristics as described in terms of cone shapes: sugar, cake, and waffle cone respectively[36,48]

FTP Cone Type	FTP Cone Depiction and Characteristics
Sugar	 • Define future goals with a high level of clarity, far into the future • Have FTPs that consist of a series of steps or paths to reach a distal future goal • Have limited the number of possible future goals • Able to identify which tasks possess endogenous instrumentality • Have avoided selves closely related to their future goals • Express desired outcomes for their future careers • Have an intrinsic reason to work, focus, and strive for learning
Cake	 • Provide limited definition of their futures

	• Have difficulty connecting their future goals to their present actions • Able to define undesired careers • Able to define characteristics of jobs they do want to have • Do not express an ideal future • Have limited or no connections from the future to the present • Do not use their future goals to create value judgments of what tasks are important • View all tasks as relevant to helping them define their future goals • Rely purely on the intrinsic enjoyment of learning
Waffle	 • Define their future goals with a high level of detail • Do not express future goals beyond that of their first career after graduation • Possess ideal and attainable selves that differ from one another • Part of their attainable self is also part of their avoided self • Do not express a desired outcome of their future career • Develop skills in the present for refinement of the future • Limit which tasks are viewed with endogenous instrumentality

Related to these cone types, a number of FTP characteristics emerged: type of future possible selves (avoided, realistic, ideal), number and characteristics of future careers, steps to and depth of future goals, and effects of future on the present[36,49,50]. One of the FTP characteristics identified in the characteristic list for the FTP model was the *academic possible self*, which can act as a motivator to students and can be a driving force for current action. In previous literature, Marcus and Nurius[41] tied self-cognition to motivation by developing the idea of a *possible self*, a view of possibility for a person that encompasses goals, aspirations, motives, fears, and threats. "Possible selves are the individual's self-relevant expectations for the future"[53] (p. 143). Related to student conceptions of wanted and avoided possible selves, Oyserman and Marcus[53,54] show that a balance of domain-specific positive/hopeful/expected selves (e.g. "I will become an engineer.") and negative/feared selves (e.g. "I may end up jobless.") assists with regulation of positive behaviors. The *depth* of a person's FTP refers to the distance into the future the person's temporal space extends, related to an FTP extension. Similar to physical distance, people experience time as close or far in different ways and for different reasons; some people have very short FTPs while others have FTPs that extend far into the future. A person's *path* (or set of goals in a person's future) can be characterized by the number of *steps* (goals) in that path; a distal future goal motivates the creation of a path of proximal sub-goals which assists in task motivation in the present. Work by Zaleski[55,56] has shown that students self-report a higher effort, striving, and persistence for distant (longer-term) goals. Additionally, this work, along with others[32,57,58], has shown that if sub-goals are necessary for a final goal (ie if the final goal cannot happen without achieving the sub-goal and the path is contingent on that success) students will work harder on the proximal sub-goals that lead to that future goal, showing an impact of future goals (including how many, in what time space, and which type) on present activities.

The above FTP characteristics, will assist in identifying connections between what students want as a future career to what they are doing in the present[36]. One such present construct, which has been researched along with FTP[3,40,59,60], is Self-Regulated Learning (SRL).

1.2.2 Self-Regulated Learning

SRL is often defined as a combination of metacognition, motivation, and behavior (also termed self-directed action)[61,62] (See Figure 1.3). SRL is shown to predict academic achievement and performance[14,63–65] and assists students to reach their learning goals[61]. While SRL combines three aspects of the cognitive and affective domains, this research focuses on the behavioral pieces of SRL, specifically study skills and goal-setting, which can be classified as cognitive, metacognitive, or motivational SRL strategies. In particular, many researchers focus on the single aspect of SRL, metacognition, which has been described as metacognitive knowledge, metacognitive awareness, self-regulation, self-awareness, or self-reflection. Metacognition can be boiled down into two pieces: knowledge of cognition and the actual actions related to regulating cognitive processes[66]. The main difference lies in the fact that metacognitive knowledge pertains to the understanding of cognitive strategies, such as when, where, and how to use them, while the processes involved in metacognition involve the actual use of those strategies. Metacognitive strategies used by self-regulated learners include planning, self-monitoring, goal-setting and self-evaluating. Similarly, cognitive strategies help students with learning and understanding[63,67] and include behaviors such as rehearsing, seeking help from people or resources, structuring an effective learning environment, and organizing[17,63,68]. SRL has also been discussed in terms of motivational constructs, such as goal orientation[19,69,70], and overall, students who self-regulate are seen to capitalize on goal-setting[71,72].

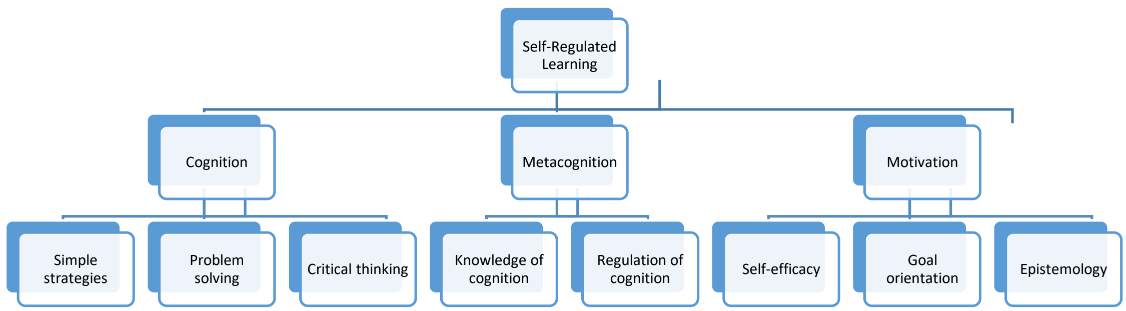


Figure 1.3: A framework for SRL, displaying the three key features in the formal definition developed in 1986[62]

Many frameworks have been established by researchers to explain SRL and its outcomes[73]. Pintrich[74] developed the **Motivated Strategies for Learning Questionnaire (MSLQ),** which contains 81 Likert-type items in sections including rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation (planning, monitoring, and regulating), time and study environment, effort regulation, peer learning, and help-seeking[74–76]. Pintrich's work is also commonly cited, but the MSLQ has been found invalid for different participant samples[77,78].

Another construct to categorize SRL strategies and student use was created by Weinstein et al.: **the Learning and Study Strategies Inventory (LASSI)**[79]. An 80-item, 5-point Likert-type item survey was developed with 10 scales: metacognitive skills (concentration, selecting main ideas, and information processing); motivational skills (motivation, attitude, and anxiety); and behavioral skills (time management, study aids, self-testing, and test strategies). These categories are also referred to as skill, will, and self-regulation. This inventory is rarely used largely due to the cost of administration and because the MSLQ is cited more frequently.

The **Student Perceptions of Classroom Knowledge Building** (**SPOCK**) **scale** was developed for Project CIRCLE[80,81] and contained four aspects of self-regulated strategic learning (knowledge building, question asking, self-regulation, and lack of regulation) and two aspects of classroom environment (student perceptions of level of teacher directedness and collaborative learning in the classroom). Self-regulated strategic learning differs from SRL in that it isolates the aspect of knowledge building within the theory. The reliability and validity scores for SPOCK appear consistent with the MSLQ[43,82] and LASSI[83]. However, all three of these scales/surveys address quantitative assessment for student learning, strategic learning, and/or SRL. While the surveys were developed based on qualitative behaviors, utilizing a survey limits the data that may be collected and thus the richness of the results. For example, surveys are able to assess if students utilized help seeking behaviors through social assistance but may not be able to determine who was utilized and for what reason (e.g. a professor to learn more about research opportunities in the field).

Zimmerman and Martinez-Pons developed a qualitative way to assess SRL by interviewing students with a structured protocol, the **Self-Regulated Learning Interview**

Scale (SRLIS)[63], and then generating an SRL framework from the elicited themes. This qualitative study documented 14 SRL categories by asking for answers from students in hypothetical learning situations[84]: self-evaluating, organizing and transforming, goal-setting and planning, seeking information, keeping records and monitoring, structuring the environment, giving self-consequences, rehearsing and memorizing, seeking social assistance (peers, teachers, adults), and reviewing records (notes, books, tests). Other SRL surveys obtain retrospective self-reports. As discussed in Chapter 2, a previously published study[85] utilized *a priori* coded reflections for second-year industrial engineers after a SRL workshop, which included definitions and examples of all the 10 condensed SRL categories[63]. The Zimmerman framework is utilized in this dissertation as it stemmed from a qualitative interview analysis of students and this work utilizes directed content analysis of interview and reflection data.

1.2.2.1 Study Cycle and SRL

Interventions using SRL are fairly common, though not often cited in the literature[86–88]. While SRL has been taught in science classrooms and students are more successful when using these strategies, programs focused on SRL are rarely rigorously researched or cited in the literature. In fact, a very recent article[89] describes a science-curriculum centered around multiple assignments which have a built-in SRL cycle of forethought, performance, and self-reflection, based on Zimmerman's work[72]. This was the first paper of its kind in the literature, focusing on building a SRL component and this cycle into the work of the students, specifically three assignments: independent research, science knowledge building, and citizen science projects. As this paper noted "most curricular interventions are based on conceptual change theory"[89] (p. 856) while their research used SRL theory as the basis of their intervention. This was a follow-up to a similar research study in a science classroom, focusing on a mixed methods study with embedded SRL as a method of increasing content and nature of science knowledge[90]. Other studies have shown that SRL in science classrooms improves student learning[91,92], but the SRL strategies of engineering undergraduates has not been fully documented.

1.2.3 SRL Intervention

To thoroughly understand the use of SRL by engineering students, an intervention was created which enhanced the "Study Cycle"[93] by introducing key pieces of SRL into a five step SRL process: previewing before class, engaging in class, reviewing after class, holding study sessions, and supplementing their learning with resources. Details about the intervention are included in Appendix C and D and can be found in Chasmar, et al.[86]. The "Study Cycle" was selected for the basis of the intervention as it is commonly utilized in workshops through the university learning center and as a model for study strategies at several other engineering-focused institutions[94–96] and in previous literature[87]. Additionally, it was a strong basis of commonly used study skills but was lacking in respect to SRL strategies. The "Study Cycle" was adapted to include all SRL themes from the SRLIS framework[63] into a workshop-style intervention to increase the fluency of the students in regards to SRL for data collection. A qualitative study was conducted to test out participant selection and reflection prompts, with the goal of understanding the SRL strategy use of undergraduate engineering students[86]. The study showed that sophomore-level industrial engineering students increased their self-reported use of SRL strategies, including all ten of the SRL themes from the SRLIS framework[63,67].

1.3 Connections

1.3.1 How do SRL and FTP connect?

Pintrich related motivation, goal-setting, and SRL when defining SRL as “an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation and behavior, guided and constrained by their goals and the contextual features in the environment”[97] (p. 453). Here, he relates SRL as a context-based, motivationally-driven, and cognitively-dedicated process. Zimmerman also related SRL to FTP, specifically goal-setting, when stating: “The goal systems of highly self-regulated individuals are organized hierarchically, such that process goals operate as proximal regulators of more distal outcome goals. These process sub-goals are not merely mechanical check points on the path to attaining highly valued outcomes; instead they become invested with personal meaning because they convey evidence of progress”[72] (p. 17). While Zimmerman theorized a micro-view of the connection between SRL and FTP in terms of goal-setting, Miller and Brickman[4] depicted a connection between self-regulation and FTP by creating a macro-model in which personally-valued (distal) future goals assist with development of proximal sub-goals, or *sub-goaling*, and thereby the regulation of these sub-goals. Thus, FTP can also be defined as "the impact on motivation for some present activity of perceiving its instrumental relationship, as a step in a longer path, to more distant future goals and threatening consequences"[58] (p. 5). Figure 1.4 shows the connection between FTP and

SRL, adapted from the Miller and Brickman model[4], which can be utilized as a framework for seeing how SRL relates to the FTP of undergraduate engineers.

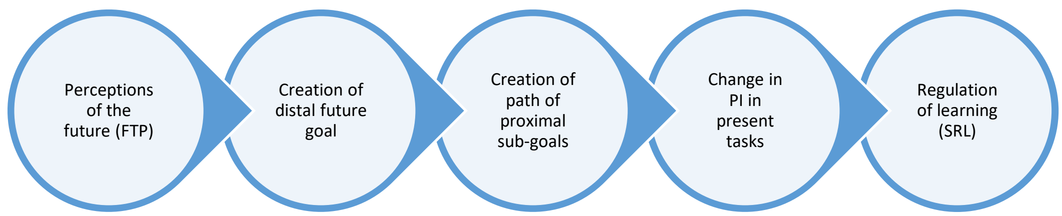


Figure 1.4: A depiction of the connections between FTP, SRL, PI, and sub-goaling that help frame our understanding of a student's creation of a distal future goal and a path of proximal sub-goals to achieve that future goal.

While SRL has been well researched[98] and many frameworks exist[61,63,98–100], specific SRL *strategies* of engineering undergraduates have not been documented. Dewitte and Lens[101] showed that students often differ in their opinion of what the term "study" means, but there does not exist research verifying what "study" means to undergraduate engineering students in particular. The first goal of this project is to identify SRL strategies utilized by undergraduate engineers.

Additionally, many studies have shown the connection between SRL and motivation, including self-efficacy[14,18,75] and goal orientation[19,70]. Quantitative and qualitative studies have shown a relationship between FTP and SRL in a broad sense[37,59,60,102,103]. Recent literature, conversely, show interest in connecting FTP and SRL[29]. This research looks to identify these SRL strategies employed by engineering students and classify the strategies by FTP-type. To move this work forward, the subtypes of mid-year engineering student FTPs must first be documented. Specifically, we hope to build connections between students' FTPs and their SRL strategy use, relating to the FTP model developed by this research team[36]. This will help define a model about students' FTPs, their SRL strategy use, and their connections for engineering undergraduates.

1.4 Research Questions

This research seeks to understand the connections between aspects of motivation (FTP) and the learning strategies (SRL) of students. This dissertation enhances completed and ongoing work to study attitudes and motivations of engineering students and their effect on student learning. Our understanding of student learning is extended to include SRL strategies. The three goals of this project are: 1) qualitatively describe and document engineering students' SRL strategy use, 2) examine interactions between students' motivations, specifically their FTPs, and SRL strategy use, and 3) study goal-setting as a connection between FTP and SRL for the engineering undergraduate population. The uniqueness and value of the project lies in its ability to provide evidence of connections between motivation and engineering students' SRL strategies, which up to this point have only been theorized or demonstrated through limited quantitative measures.

Based on the cone model and key FTP constructs, *we seek to characterize students by FTP type, and then further study the SRL strategy use of students within FTP types while examining the connections between the two frameworks.* This research utilizes a sequential explanatory mixed methods design, focusing on a multiple case study with research questions as follows:

RQ1: What SRL strategies do engineering students utilize?

> RQ1.1: How do engineering undergraduates adopt SRL strategies in a course required for their major?
>
> RQ1.2: What SRL strategies related to task-level sub-goaling do engineering undergraduates utilize?

RQ2: What are the connections between students' FTPs and their use of task-specific SRL strategies?

> RQ2.1: How do students' FTP attributes relate to their use of SRL strategies?
>
> RQ2.2: In what ways do the SRL strategies differ among FTP types?
>
> RQ2.3: How does sub-goaling connect students' FTPs and their use of SRL strategies at the task level?

1.5 Researcher Perspective

I am the main researcher, interviewer, and author for the research in this dissertation. I have a background in mathematics, including teaching at the college level, and have earned BS and MS degrees in Mathematical Sciences. Additionally, through my past positions in learning centers, I came into contact with students, student leaders, and professors in engineering and related fields. In particular, I have worked at two heavily

STEM- and engineering-focused institutions and have witnessed the transitions that students go through during their engineering undergraduate experience. These roles made me interested in the experience of engineering undergraduates, how they develop their career plans, and the SRL strategies they use to succeed through their programs.

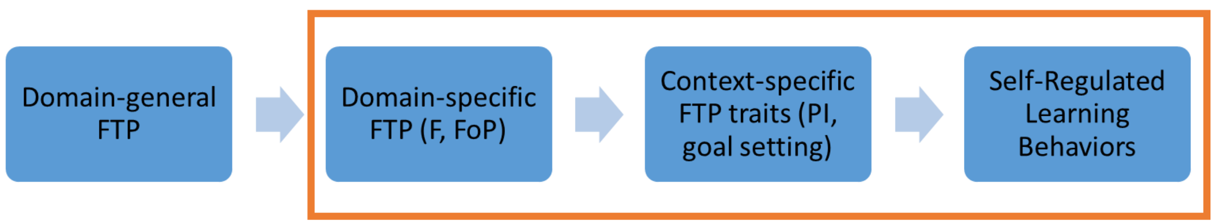
Professionally, I have served as a tutor coordinator and academic coach, which required knowledge of SRL and related skills that students need to succeed in higher education. I have seen first-hand the impact of SRL strategies on student grades and overall academic success. Additionally, I have seen that students are able to learn SRL strategies and use them successfully in their courses through workshops (many of which I ran) that set students up with new and essential SRL strategies. Additionally, through these positions, I have worked one-on-one with students as an academic coach, primarily for STEM undergraduates, providing sessions discussing SRL strategies, career advice, and goal-setting.

As a service to the tutoring community, I serve on the board of a national tutoring organization, which provides professional development to tutoring professionals across the country. Through this network with other learning center professionals, I have learned how students learn, adapt, and change at different institutions. Since most tutoring across the country is focused on STEM students, as STEM courses are considered to be particularly rigorous, the professional development provided through my organization is often STEM-focused. I have also learned about “research to practice” to best support STEM students.

1.6 Outline of Chapters

The information in Chapters 2 through 7 are outlined below. The voice in each chapter may vary as the chapters are written for publication with different journals in mind. Chapter 2 details a qualitative exploratory study which utilized the SRLIS framework to examine the SRL strategy use and goals of second-year industrial engineering students in a major-required course before and after an SRL intervention during class time. This chapter introduces the types of SRL strategies engineering students are using, which has not been qualitatively included in the literature.

The rest of this dissertation research, described in Chapters 3 through 7, details the use of a sequential explanatory mixed methods design, focusing on a multiple case study. Chapter 3 introduces a pilot of this work which tested the methods and participant selection process and describes the connections between FTP and SRL for the same group of IE participants as in Chapter 2. Chapter 4, a quantitative chapter written in passive voice, describes the analysis of the MAE survey and selection of a cluster analysis of a group of second-year engineering students in required materials science and engineering (MSE) and IE courses. In Chapter 5, case study participants are selected from the MSE course, and the selection process is described using quantitative and qualitative data. In Chapter 6, the three case studies are described, along with a cross case analysis to generalize a model based on the three participants. Chapter 6 is written in active and third-person voice as it reveals the results of three case study participants. This chapter documents these students' FTPs, their experience with SRL, and SRL's connection to their FTP. In particular, these theories were operationalized by collecting multiple types of data, including qualitative and quantitative, thoroughly describing these case studies, and interpreting the findings. The Miller and Brickman model, the SRLIS framework, and the FTP cone model was utilized to see the connections. Participants were selected based on their context-specific FTP, as these students are engineers in engineering courses and of interest is their task-specific behaviors related to SRL. This selection is shown via the orange box in igure 1.5. Finally, Chapter 7 describes conclusions, future work, limitations of this research, and implications for research and practice.



igure 1.5: The focus of this research is a top-down approach for FTP focusing on domain-specific FTP, context-specific FTP, and SRL in the present

1.7 Quality

The *Quality Framework* (qualifying qualitative research quality)[104,105], created to address reliability and validity in qualitative research, was applied for all the work described in this dissertation. The validity and reliability terms within the Quality Framework are defined below[104]:

> **Theoretical validation** focuses on the fit between the social reality under investigation and the theory produced.

Procedural validation suggests incorporating features into the research design to improve this fit.

Communicative validation accounts for co-construction of knowledge in the social context under investigation as well as within the research community.

Pragmatic validation examines the extent to which theories and concepts are compatible with the empirical reality.

Process reliability provides the necessary conditions for developing overall validation through strategies aimed at making the research process as independent from random influences as possible.

In addition, **Ethical validation** was later added to the Q3 framework to address the following two questions: "Do the ways in which we generate and disseminate our findings and their ultimate use do justice to the participants' lived experiences and their commitment to sharing them with us? What are the impacts of our research for the social reality investigated and for similar social realities?"[106] (p. 11).

Additionally, the *Mixed Methods Legitimation Model* by Onwuegbuzie, et al.[107,108] was considered during every aspect of this dissertation: design of the research, data collection, data analysis, etc. Originally defined by external and internal threats at the research design, data collection, data analysis, and data interpretation phases, qualitative and quantitative quality concerns were combined into one framework with nine types of legitimation[108]:

Sample Integration: The extent to which the relationship between the quantitative and qualitative sampling designs yields quality meta-inferences.

Inside-Outside: The extent to which the researcher accurately presents and appropriately utilizes the insider's view and the observer's views for purposes such as description and explanation.

Weakness Minimization: The extent to which the weakness from one approach is compensated by the strengths from the other approach.

Sequential: The extent to which one has minimized the potential problem wherein the meta-inferences could be affected by reversing the sequence of the quantitative and qualitative phases.

Conversion: The extent to which the quantitizing or qualitizing yields quality meta-inferences.

Paradigmatic mixing: The extent to which the researcher's epistemological, ontological, axiological, methodological, and rhetorical beliefs that underlie the quantitative and qualitative approaches are successfully (a) combined or (b) blended into a usable package.

Commensurability: The extent to which the meta-inferences made reflect a mixed worldview based on the cognitive process of Gestalt switching and integration.

Multiple Validities: The extent to which addressing legitimation of the quantitative and qualitative components of the study result from the use of quantitative, qualitative, and mixed validity types, yielding high quality meta-inferences.

Political: The extent to which the consumers of mixed methods research value the meta-inferences stemming from both the quantitative and qualitative components of a study.

For this research, the "insider" mentioned in **Inside-Outside** legitimation is considered a mid-year engineering student.

CHAPTER TWO

2. Use of Self-Regulated Learning Strategies by Second-Year Industrial Engineering Students

This paper was presented in Seattle, WA at the 2015 American Society for Engineering Education Annual Conference and Exposition and appears in the conference proceedings: Paper ID #12285. The following modifications were made to include the paper in this dissertation: 1) double-spacing; 2) typos were edited; 3) references to figures and tables were modified to indicate new numbers; and 4) all references and appendices were combined with the rest of the dissertation and listed at the end of the document.

Chasmar, J., Melloy, B. & Benson, L. Use of Self-Regulated Learning Strategies by Second-Year Industrial Engineering Students. *ASEE Annual Conference and Exposition* (2015).

2.1 Abstract

The Study Cycle is a set of guidelines rich with Self-Regulated Learning (SRL) techniques that enables students to plan, prepare, and enact their studying by focusing on five comprehensive steps: previewing before class, engaging in class, reviewing after class, holding study sessions, and seeking help as a supplement. This paper reports on initial findings of a qualitative study in which a workshop on the Study Cycle was taught to a class of second-year industrial engineering students as an intervention, aiming to understand effects of the module on engineering students' SRL strategy use in an engineering course. Students self-reported SRL strategy use in a one-minute paper pre-workshop and two sets of post-workshop reflections. This paper examines which

components of the Study Cycle students self-report as being useful in their engineering courses prior to the module and their perceptions of effective study strategies after the module. Main findings include that students self-reported SRL strategies from all ten categories which were analyzed via *a priori* coding: self-evaluation, organizing and transforming, goal-setting and planning, seeking information, keeping records and monitoring, environmental structuring, self-consequences, rehearsing and memorizing, seeking social assistance, and reviewing records.

2.2 Introduction

The term "sophomore slump" has been widely used in literature after being coined by Freedman in his 1956 paper detailing the four years of the undergraduate experience[109], but only in the last fifteen years has the sophomore year been addressed in education research and publications[110–112]. Evidence suggests that the second year can have a major impact on students' academic success[113]. Additionally, the second year is crucial for retention of university students[114] and retention in the major[115]. Though the second year should be a time when students are getting involved in professional, social, and academic organizations, sophomores often feel less connected to campus due to the lack of programming specifically designed for them[116]. Sophomores have also been shown to be the least academically involved out of the four typical student levels (freshmen, sophomores, juniors, seniors)[117]. To promote student academic success, persistence, and learning, academic programming can be added during the second year[118]. Since the second year is often the first opportunity for students to enroll in major-specific courses[119], this is a natural area for the focus of research on how to retain students in science and engineering.

In *Visible Solutions for Invisible Students: Helping Sophomore Succeed*, Gardner[117] states that second-year students are less likely to be engaged in their own learning, a key piece of SRL. Studies have shown that SRL strategy use is positively correlated with academic performance[63], as well as motivation, and these SRL strategies are teachable[65]. Lemons and Richmond[120] stated that programs designed to help sophomores should focus on mentoring, individual counseling, and special programming to provide support through the "sophomore slump." One type of special programming, an intervention, has been attempted to help students adopt SRL strategies[121], and many of the techniques utilized to teach students these skills have shown to be successful[121,122]. Second-year courses are typically content-heavy, warrant better study skills, and require increased study time, thus leading to greater stress from internal and external sources[123]. Though programs have been put into place to help retain freshmen engineering majors[124,125], not many studies have focused on initiatives to help sophomore industrial engineering (IE) students. This project aims to understand effects of a SRL workshop/intervention, framed by the Study Cycle, on IE students' SRL strategy use in an IE course.

2.2.1 Self-Regulated Learning

At a symposium at the 1986 American Educational Research Association (AERA) annual meeting, a group of researchers agreed on a definition of SRL combining three aspects of cognitive and affective domains that help students achieve their academic goals: motivation, metacognition, and self-directed action[61]. Later, Zimmerman and Schunk coined the phrase “masters of their own learning”[84] (p. 166) to describe students who practice SRL techniques[126]. Self-regulated learners are seen to have high motivation in terms of self-efficacy and intrinsic task attributions[127]. Metacognitive strategies used by self-regulated learners include planning, self-monitoring, goal-setting, and self-evaluating[63,67]. Cognitive strategies help students with learning, understanding, and remembering[63,67] and include rehearsing, seeking help from people or resources, structuring an effective learning environment, and organizing[17,63,68].

Zimmerman and Martinez-Pons[63] developed a structured interview protocol, the Self-Regulated Learning Interview Scale (SRLIS), to analyze SRL strategies, or “actions and processes directed at acquiring information or skill that involved agency, purpose, and instrumentality perceptions”[128] (p. 2), used by students. The outcomes of this study determined a new framework with 14 documented SRL categories: self-evaluation, organizing and transforming, goal-setting and planning, seeking information, keeping records and monitoring, environmental structuring, self-consequences, rehearsing and memorizing, seeking social assistance (peers, teachers, adults), and reviewing records (notes, books, tests). This study included definitions and examples of all fourteen of the SRL categories[63]. In 1988, this framework was further validated by the analysis of teachers’ observations[67]. This interview protocol asks for answers from students in hypothetical learning situations where other SRL surveys obtain “retrospective” self-reports[84]. This IE SRL research study utilizes the SRLIS framework as it was the most appropriate for the qualitative data.

Hattie et al.[122] showed that a multi-strategy program can have successful effects on student learning and are more generalizable than a single-strategy approach. A multi-strategy intervention with a strict focus and narrow scope that focuses on "teaching, modeling, and practicing"[65] (p. 59) can help students learn multiple strategies they can apply to their learning[129]. Based on past literature, Schunk and Zimmerman[65,126] suggest that multi-strategy initiatives include all three foundations of SRL to promote the appropriate skill and will: motivation, cognition, and metacognition. Thus, the intervention utilized in this research includes a variety of SRL techniques framed by the Study Cycle.

The Study Cycle

The "Study Cycle," adapted from the "Learning Cycle" created by Frank Christ[93] and outlined in Appendix A, is a set of guidelines for students rich with SRL techniques that enables students to plan, prepare, and enact their studying by focusing on four comprehensive steps: previewing before class, engaging in class, reviewing after class, and holding "intense" study sessions. Supplement has been added as a piece of the study cycle as seeking help is a key SRL process of successful students[63]. Key pieces of self-regulation included in the updated study cycle are goal-setting, planning, monitoring, evaluating, and help seeking.

Teaching the Study Cycle during a class period has shown to reinforce aspects of metacognition and to correlate with increased academic performance in students in a general chemistry course[87]. While performance in first-year, general education courses is vital for engineering students to move through the curriculum, the transition of undergraduate engineering majors into the rigorous coursework in the engineering departments is specifically of interest. This paper reports on initial findings of a study in which a module on the Study Cycle was taught to a class of second-year IE students. More details about the Study Cycle can be found in the Methods section of this paper, which outlines the workshop that was utilized as the intervention in this project.

2.3 Research Purpose

As the first step in this project, this paper examines both the components of the Study Cycle students self-report as being useful in their engineering courses prior to the module and their perceptions of effective study strategies after the module.

2.4 Methods

Students in this study were enrolled in a sophomore-level IE class, Sophomore Seminar in industrial engineering, at a southeastern land-grant institution. This class, a required one -credit hour seminar offered in the fall semester of the sophomore year, is intended to orient students to the IE program. This course was chosen to introduce the module because it is the transitional course between other programs/departments and the IE major, and as such the content is both timely and relevant.

The majority of the students enrolled in the class are sophomores and juniors; the former have transferred from the first year engineering program and the latter typically have transferred from other engineering majors. In this fall, the percentages of sophomores and juniors enrolled were roughly 50 and 35%, respectively (based on credit hours completed).

In this fall semester, students in the Sophomore Seminar course attended a study skills workshop based on the Study Cycle as a class assignment (N=81) as part of a qualitative study. Students were not included in the data pool if they did not complete any single portion of the intervention but were allowed to complete an alternative assignment; therefore, participants may be labeled a number greater than N. The number of students completing each assignment varied and is reported with the results in the next section. Students were given course credit for a one-minute paper, workshop attendance, one-week post-workshop reflection (Reflection 1), and end-of-semester reflection (Reflection 2). To improve the level of metacognitive reflection[130], students were asked to identify a single course during all responses.

Prior to the workshop, students identified an IE course as the focus of their reflections. Additionally, each student wrote a one-minute paper responding to the prompt: "What strategies do you find successful that you use to study for this particular course? Why?"

The intervention was a one hour and fifteen-minute workshop based on the Study Cycle which introduced a sundry of SRL techniques nestled into the Study Cycle framework: preview, engage, review, study, and supplement. The supplement section included additional self-regulatory strategies specific to the institution, such as seeking help from campus resources. The students were given a handout (see Fig. 1 in Appendix A) to reference during and after the presentation. More details about the intervention can also be found in Appendix B.

One week after the workshop, students submitted a reflection on strategies they will use in the course they identified in their original one-minute paper. After stating if they had previously seen strategies outlined in the workshop students were asked for a 500-word reflection on the following:

- How do you think your study habits will change, if at all, from the strategies you utilize that you discussed in the one-minute paper?
- Based on the presentation you attended, set personal goals of strategies to try when studying for the class you identified in the one-minute paper.

At the end of the semester, the students were asked to write a second 500-word reflection about strategies they had utilized in their specified course since the workshop. The following prompts were used:

- Did you change your study strategies after attending the workshop? If so, how, and if not, why not?
- Recall that you set personal goals of strategies to try when studying for this class. Which of the strategies (that you set as goals), if any, did you use? How did you benefit from them, if at all (if you didn't use any of these strategies, then write n/a)?

- Did you utilize any strategies that you did not include as goals? What were they (if you didn't use any such strategies, then write n/a)? How did you benefit from them, if at all (if you didn't use any such strategies, then write n/a)?

The one-minute papers, Reflection 1, and Reflection 2 were all given several read-throughs and then coded qualitatively. First, *a priori* coding was used to identify phrases in the responses that aligned with categories adapted from the 14 SRL subscales [63]; ten categories resulted from collapsing codes: "reviewing records" formed from "reviewing tests," "reviewing textbooks," and "reviewing notes" and "seeking social assistance" formed from "seeking social assistance from peers," "seeking social assistance from teachers," and "seeking social assistance from adults." The final two categories have been collapsed because the differentiation between which social group or which type of record reviewed is of little interest in this study. Additional themes were allowed to emerge from the data. Phrases were highlighted as codes in RQDA, a qualitative data analysis package in the statistical software R. Because one-minute papers and reflections were self-reported by undergraduate students, only ideas that indicated some level of specific reflection were coded. For example, for Reflection 1, the importance of the data was the goal-setting; therefore, "…if a homework problem is giving me difficulty, I like to be able to recognize that I am able to come back to the problem after sleeping on it, and I can usually get the problem right after doing that…" (Participant 15, Reflection 1) was not coded as the participant did not state a specific goal. The same student later set a very direct goal, which was coded as completing homework: "As a personal goal and strategy for my IE 2800 class then, I will set the goal and strategy of completing all the homeworks in a timely manner."

2.4.1 Reliability and Validity

Walther, Sochacka, and Kellam[104] established a quality assurance framework, Q^3, looking to examine the validity and reliability of qualitative research: theoretical, procedural, communicative, and pragmatic validation, and process reliability. To satisfy the *theoretical validity* portion of this framework, SRL has been utilized as the context of this research, specifically following the work of Zimmerman & Martinez-Pons [63]. Additionally, experts in the field, such as Saundra McGuire, a former director in the learning center community, retired professor chemistry from Louisiana State University, and Science Education researcher, and colleagues from engineering education community were consulted in the research design to ensure *theoretical and procedural validity.* During the research design process, an IE undergraduate reviewed reflection questions to confirm the correct interpretation and to make sure IE undergraduates would understand how to complete the assignment, which lends to *communicative validity*. Representative quotes were selected from the one-minute papers and two sets of reflections as well. For *pragmatic validity*, students were asked to self-report on pre-existing strategies in a one-minute paper before the workshop and then to reflect on strategies that were utilized due to their attendance at the workshop. The one-minute paper serves as a baseline for the strategies learned through the SRL workshop. To ensure *process reliability*, attendance was taken to note the students who attended so that the legitimacy of post-reflections could be confirmed; field notes were taken by a trained colleague during the Study Cycle workshop to confirm student participation, and a debrief was held directly after the workshop. For further reliability, two researchers worked to consistently code all one-minute papers and reflections.

2.5 Results and Discussion

Students were asked before the Study Cycle workshop to reflect on a specific course, preferably in IE. Several different courses were listed, including calculus and physics, but the sophomore and junior-level classes predominately selected were an IE-focused operational methods course and a probability and statistics course for IE majors, respectively. These selections were not surprising, as both courses involve mathematics and modeling, have calculus courses as prerequisites, and are fairly rigorous. When asked about study strategies during the one-minute paper and both sets of reflections, students would talk about these strategies in the context of the course.

2.5.1 One-Minute Paper (Before workshop)

Results of the one-minute paper analysis (N=77) show students identified seven of the ten categories before the workshop: goal-setting and planning, information seeking, organization and transformation, rehearsing and memorizing, reviewing records, seeking social assistance, and self-evaluation.

Students self-identified several **goal-setting and planning** strategies, including studying several days in advance of an exam, beginning homework early, and attending class. Additionally, several students mentioned keeping a calendar and other time management strategies. Students mentioned reading the book for a variety of reasons: to prepare for an exam, to prepare for class, to look up information to complete homework, or fill in their notes. Students mentioned applying methods from class to complete a homework assignment or lab experiment. This “use methods from class” code was placed into the **information seeking** category because the students are actively trying to find answers during lab or other instance and refer to notes/methods used in class. Other information sources used by students before the workshop include videos, note summaries, and other extra materials posted by professors on Blackboard, as well as solution manuals.

Students outlined **organization and transformation** techniques including: creating a note sheet, highlighting key ideas, taking notes about the readings, and working real-world example problems. Many **rehearsing and memorizing** techniques were elaborated including making flashcards, previewing before class, rereading the chapter, reworking homework and other problems, rewriting notes, and utilizing other memorization techniques. **Reviewing records** was frequently mentioned including review class materials, reviewing homework, reviewing materials for an exam, and reviewing pre-worked examples from class or the textbook. Over half of the students mentioned reviewing notes from lecture. A handful of students self-reported **seeking social assistance**, such as working with other students or attending office hours, but no students mentioned visiting with a tutor or advisor, asking for help from a friend or peer, or utilizing any campus resources. **Self- evaluation** techniques listed were limited, including taking practice exams, checking homework solutions, and creating problems. Additionally, none of the students mentioned **self-monitoring**, **self-consequences**, or **environmental structures.**

While many strategies were mentioned by students, the majority were time management (**goal-setting and planning**), memorizing techniques (**rehearsal and memorization**), or review of lecture materials (**reviewing records**), and often times the strategies were very vague: "I read the material assigned" (Participant 40, one-minute paper). Strategies from these three categories alone will not foster academic success or allow persistence in the IE major.

2.5.2 Reflection 1 (One Week Post-Workshop)

Reflection 1 (N=68) was due one week after the students attended the Study Cycle workshop during class time, in which students set goals of study strategies to try based on the presentation. Many students listed multiple goals, and strategies from each of the ten categories were mentioned.

A handful of students set **Environmental structures** goals to alter life habits such as sleeping or eating in a healthier way and changing their study environment:

> Distractions are a huge issue for me so I will try to go to a quiet place to study such as the lower floors of the library, try not to look at my phone for periods at a time, and make sure that I am not hungry when I am studying. (Participant 18, Reflection 1)

A small number of participants set **Self-consequences** goals to utilize a reward system:

> I also am going to set up rewards for accomplishing assignments, or reading, as in, if I finish a goal, I will reward myself by watching my favorite tv show, or going running. (Participant 62, Reflection 1)

While many students listed some aspect of **Goal setting and planning** as a goal, some students specifically mentioned having never utilized any form of organizer or planner, while others felt able to renew their time management goals due to the workshop. One student described how "the studying [he had] been doing has already paid off in stress relief alone":

> If I can implement some of the study habits we discussed at the presentation like studying a little everyday as well as starting to study much a week in advance to major tests or exams than I will be in a much happier place. I wouldn't have to be trying my hardest to remember things I have no idea how to do and stressing myself out right before the test. … I have a math exam next week and I have already started studying for it just like I had planned. (Participant 12, Reflection 1)

Many students mentioned goals of taking breaks while studying, coordinating a study plan, studying the hardest material first, or starting to study for an exam early.

Many students no longer referenced **Information seeking,** such as checking the posted videos to find answers or using methods from class. Instead, students set goals to fill in their notes. They often set goals to utilize the textbook or internet to figure out how to solve a problem or find information:

> For now, I believe that I will put more emphasis on coming to classes already knowing the information to be covered. Basically, I would like to try to learn as

> much as I can from the book, online or from examples before even showing up in class. (Participant 30, Reflection 1)

The Study Cycle was adapted for this workshop to focus on transforming information during study sessions. Students set **Organization and transformation** goals to summarize material in their own words and mentioned classifying, highlighting, or writing down "key points" (Participant 62, Reflection 1) while reading or studying:

> If I start writing summaries of my notes at the bottom of the page I will be more motivated to study because I will not feel as overwhelmed. (Participant 76, Reflection 1)

Many students mentioned utilizing a more organized note taking setup, creating diagrams, outlining notes and material, and summarizing to rearrange information for understanding to "cement" (Participant 73, Reflection 1) their understanding as goals.

While only a few students mentioned previewing before class and reviewing after class in the one-minute papers, many students were specific about **Rehearsing and memorizing** strategies they would use to prepare for class and to study after to "reduce the amount of time it takes…to complete homework and … need to study prior to an exam" (Participant 11, Reflection 1). Preview strategies included reading or skimming the text book and attempting homework problems. Reviewing strategies included rewriting notes, working or reworking problems, and writing down important equations. Students also mentioned making flashcards and utilizing memorization techniques.

To prepare for future assignments or exams, students set **Reviewing records** goals of reading assignments, reviewing class materials, examples, homework, notes, etc. One new thing mentioned included discussing materials to review them.

After attending the Study Cycle workshop, students set **Seeking social assistance** goals to attend tutoring or other learning center programs and utilize campus resources, such as professors, advisors, teaching assistants, peers, and the Writing Center. Utilizing these types of resources on campus was not mentioned as a strategy pre-workshop, with the exception of one student who specified that he would look for help but did not mention where.

Students mentioned setting **Self-evaluation** goals of evaluating their performance on exams after receiving their scores back, specifically to analyze where they went wrong and learn how to improve. They also hoped to track their progress while studying "to see if the strategies [being used are] helping… actually learn [the] material" (Participant 60, Reflection 1). Students also explained, in different ways, that they wished to ensure that they understand the material: by completing or reviewing extra problems, checking "mathematical steps" (Participant 64, Reflection 1), and creating their own problems.

The majority of students set **Self-monitoring** goals to engage more in class: better preparation for class, sitting in a less distracting spot, or changing how they listened in class (by getting rid of computers or cell phones). Many students mentioned the self-monitoring activity from the workshop and set goals to monitor their own attention during class and study times. Taking notes during lecture was mentioned as a way to keep attention during lecture, something that was mentioned, but less frequently, in the one-minute papers.

Overall, the participants set multiple goals in Reflection 1, but most were not “SMART.” Students set goals that crossed categories, such as Participant 62 who attended lectures and finished homework early to preserve time to seek help from the professor before the due date.

2.5.3 Reflection 2 (End of semester)

Students (N=72) reflected on all ten of the categories and gave specific examples of techniques they tried of each type. The final number of students who attended the intervention and completed the one-minute paper, Reflection 1, and Reflection 2 was 55. **Environmental structures** were described**,** such as avoiding distractions, changing life habits and their study environment. Students most often mentioned finding somewhere quieter, such as the library. Students revealed intentionally avoiding specific distractions:

> I have been training my attention span by eliminating things that distract me like my cell phone, social media on my laptop, friends, and other forms of communication. After practicing these methods for the past month or so, I have developed a stronger attention span in class and during my study time. (Participant 46, Reflection 2)

A few students mentioned **Self-consequences,** specifically utilizing rewards such as a snack or watching television after studying, while more had set a reward system as a goal in Reflection 1.

Participants mentioned **Goal setting and planning:** attending more class days, reviewing material on a schedule, beginning to study for exams earlier than before (i.e. less cramming), beginning homework early, setting study goals, and taking breaks, sometimes with a specific time limit. Participants reflected on time management changes, such as scheduling study times throughout the week or specifically scheduling out a study session, as in this example:

> After the workshop, I began to write very detailed study plans for myself. I allotted time to work on each assignment and scheduled breaks every now and again to break up the work. Not only did this prevent me from forgetting about any assignments, it helped me manage my stress a lot better. Sitting in the library for hours doing work non-stop is miserable however, knowing that I have scheduled break times makes my study time more bearable. (Participant 64, Reflection 2)

For **Information seeking**, students wrote less about checking resources such as the book or internet and more about filling in their notes and referring to posts by the professor such as videos, PowerPoints, and other supplemental course materials. Additionally, participants reflected on their use of campus resources and mentioned specific examples, which were not mentioned in the one-minute papers or Reflection 1.

Participants reflected about the value of their experience utilizing **Organization and transformation** techniques**:** summarizing material, writing down summaries of readings, and creating summary sheets to help with studying. Many students began taking neater, more organized notes and spent time reorganizing notes after class and while studying. Participants also tried and altered the Cornell Note Taking method or made note of a method they utilized. Other techniques related to organization and transformation of materials were tried:

> I have found myself organizing material into what I already know, the concepts that are easy for me, and the concepts that are hard for me. This allows me to pinpoint difficult concepts, and allocate more studying time for topics that will take more time to teach myself. This allows me to feel more comfortable with the material, and it makes my study time more effective. (Participant 21, Reflection 2)

A large number of participants mentioned **Rehearsing and memorizing** including utilizing a preview and/or review technique to rehearse the material, especially reviewing the previous days notes just before class. Preview and review, as taught in the Study Cycle, were utilized by students to review records before and after class such that they will have seen the material multiple times and remember it better. Students who spoke about reworking problems had not mentioned this as a strategy before the workshop:

> After the seminar, I did find that practicing more increased my confidence in answering questions. Instead of doing the bare minimum I decided to always do two or three more problems. This gave me more familiarity with certain types of questions and made me more confident with my answers when solving problems. (Participant 78, Reflection 2)

Students did not reflect on working problems from the book, online, etc. but spent more time referencing rewriting their notes and reworking problems shown in class.

For **Reviewing records**, a large number of participants mentioned using reviewing the previous days notes just before class, which is dual coded in **rehearsing and memorizing**. This type of review is used by students to not only rehearse the material but also to prepare them for class. Overall, participants mentioned reviewing more often, such as every day or multiple times during the week. They mentioned reviewing notes from the professor and other class materials.

> I changed the fact that I would come into the lectures essentially "blind" to the topics we would cover that day in class. I benefitted in that I was not as stressed in class and felt like I had an advantage at the beginning of class because I already knew what was coming. It was like playing defense but you already knew what the other team was going to do on offense. This made it easier to combat the tougher concepts and learn more in class because I would not get discouraged when there was something that I did not understand initially. (Participant 5, Reflection 2)

Participants reflected on **Seeking social assistance** and specifically mentioned working in groups to study and review material with peers. They also utilized peers to assist in answering questions and fill-in their notes. Students attended tutoring and used other campus personnel as resources, asked more questions during and after lectures, and mentioned attending office hours, sometimes for the first time ever. Participants also mentioned making notes of questions during lecture to ask the professor or TA directly after class.

In Reflection 2, students more commonly **self-evaluated** their progress in a class, how well they were studying, and how well they were reaching their study goals:

> First, I spend a few minutes planning and setting goals outlining what I would like to accomplish… I then reflect on what I have already learned and analyze my progress towards the goals I have set for myself. I then continue studying until I am confident that my goals have been met. (Participant 79, Reflection 2)

One of the categories with the largest change between the one-minute papers, Reflection 1 and Reflection 2 was **self-monitoring**. Some students set monitoring their attention as a goal but this was most frequently mentioned in Reflection 2 as a strategy that was successfully used during the semester. Students asked questions during class, purposefully paid extra attention, rid themselves of distractions, and sat in areas of the classroom and engaged in activities, such as note taking, to pay more attention during class.

All codes and categories for the one-minute paper, Reflection 1, and Reflection 2 sets are reported in Table 1 in Appendix C. Though students reflected many changes in study strategies, one limitation of this study is that all data was self-reported by the participants. Additionally, the one-minute paper, Reflection 1, and Reflection 2 were all required assignments, and students were penalized for not completing any of the responses.

Though the overall outcome of the intervention appears positive, the qualitative analysis of self-reported data may have been biased by the researcher's background in learning support.

Students self-reported positive changes in attitude and academic performance after utilizing strategies from the Study Cycle. Participants mentioned increased exam and final grades, greater knowledge retention, decreased study time necessary to prepare for exams, greater confidence in their knowledge of the material, and less stress while studying and around exam time. Students also revealed that they had not been studying enough before the workshop and that they were able to enjoy college life more after regulating their study habits.

2.6 Conclusions

Overall, participants utilized less of the Study Cycle tools than they set as goals, which was to be expected. Students reported utilization of many new SRL strategies after the intervention; the main items that were tried successfully were previewing before class, reviewing course materials, working with peers to get questions answered, and transforming and organizing notes and other course materials. Students also utilized planning and goal-setting strategies, along with time management techniques such as planning study sessions, all specified in the workshop. Utilizing the Study Cycle as a framework for SRL techniques appears to be beneficial as students can easily grasp and use the examples detailed.

2.7 Implications for Practice

Based on results from student reflections, certain aspects of the Study Cycle workshop could be altered to more clearly and succinctly convey SRL strategies. First, the workshop should be shortened to an hour to keep students' attention; a break in the middle or more frequent activities (such as more frequent self-monitoring check-in's) would yield more student engagement. The presentation should focus less on note taking strategies and more on ways to transform information, with supplemental readings attached. The addition of the "supplement" part of the Study Cycle appeared to be extremely valuable as students self-reported use of campus resources, peers, TA's, and professors as a result of this section and could use more time.

CHAPTER THREE

3. Future Time Perspective and Self-Regulated Learning: Multiple Case Studies in Industrial Engineering

This paper was presented in New Orleans, LA at the 2016 American Society for Engineering Education Annual Conference and Exposition and appears in the conference proceedings: Paper ID #15223. The following modifications were made to include the paper in this dissertation: 1) double-spacing; 2) typos were edited; 3) references to figures and tables were modified to indicate new numbers; and 4) all references and appendices were combined with the rest of the dissertation and listed at the end of the document.

Chasmar, J. & Benson, L. Future Time Perspective and Self-Regulated Learning: Multiple Case Studies in Industrial Engineering. *ASEE Annual Conference and Exposition* (2016).

3.1 Abstract

This research paper is a pilot of a larger, mixed methods study that aims to capture the experience of sophomore engineering students' Self-Regulated Learning (SRL) strategy use and the connections with the student's motivation with respect to the future. The overarching goal of the project is to understand the motivations and attitudes of undergraduate students in engineering, which is vital to answering the call for increasing the number of engineering graduates. Our project aim is to study engineering students' Future Time Perspective (FTP) and how their FTP affects their use of SRL strategies. The quantitative portion of this study describes a cluster analysis of data from a motivation survey that characterizes students' FTP (n=118). The qualitative portion

consists of case studies (n=4) which assess connections between students' FTP and SRL use. The cluster analysis showed three clusters of student FTPs. Interviews showed that clustering matched the FTP interview results, a variety of SRL strategy use among FTPs, and connections between FTP and SRL including perceived instrumentality and a timeline of short and/or long term goals. Future work will focus on the connection between FTP and SRL with the intent that practitioners may use this work to create programming related to these themes to increase SRL use among undergraduate engineering students.

3.2 Introduction

The U.S. workforce is in need of a large number of well-educated science, technology, engineering and mathematics (STEM) graduates[131], and education and psychology research has shown that motivation has an effect on student success in STEM fields[29,126,132]. As described by the Future Time Perspective (FTP) theory, motivational attributes have been shown to positively affect student achievement and persistence[24]. Additionally, Self-Regulated Learning (SRL) has been positively linked with increased self-efficacy of undergraduates[127]. FTP and SRL have often been researched separately, but previous literature has reported that there is a link between these two areas[4,13,29,37,60,133]. We seek to observe the student experience in terms of FTP and how FTP affects student task-specific behavior in terms of SRL, thus investigating this link for engineering students. This paper describes a pilot project aiming to study industrial engineering (IE) students' FTPs and how these views of the future affect how they regulate their learning in the present.

3.3 Background

In the engineering education and education psychology realms, FTP has been defined as "the present anticipation of future goals"[25]. Quantitative work studying FTPs of engineering students featured the Motivation and Attitudes in Engineering (MAE) survey, which includes Likert-type FTP items focused on students' perceptions of the future, perceived instrumentality (PI), and effects of the future on present tasks (Appendix D). Perceptions of the future involve time orientation (how people generally focus on the past, present, or future[25]), perception of time (an individuals' positive or negative perception of the future[25]), and other characteristics. PI has begun to appear as a connection between SRL and FTP and can be defined as how important students view present tasks for their future/goals[13,60,134,135]. Effect of the future on present tasks (future on present) refers to how a student's future goals are influencing what they do in the present. Characteristic categories of FTP have been identified in previous quantitative and qualitative work of engineering undergraduates[36,136]. Within these categories of student FTPs, characteristics that distinguish between different student FTPs have emerged[36,49,50] including: steps to future goals, depth of future goals, number and type (avoided, ideal, and realistic) of future possible selves, effects of future on the present, and characteristics of future careers. These FTP characteristic differences can be used to distinguish between students in terms of their temporal motivations, particularly when conducting qualitative analysis of interview data.

Students who practice SRL use metacognition, motivation, and behaviors to regulate their own learning and utilize methods, such as evaluating (metacognitive) and organizing (behavioral), to reach their learning goals[63,67]. Additionally, students who are self-regulated "perceive themselves as self-efficacious, autonomous, and intrinsically motivated" (motivational)[67]. While the literature defines SRL in many ways, one underlying theme connects all SRL research: students achieve at a higher level academically when they regulate their learning[12,63,67,137]. SRL has been operationalized to measure aspects of students' metacognition, motivation, and behaviors related to their academic self-regulation, such as the Self-Regulated Learning Interview Scale (SRLIS) developed by Zimmerman and Martinez-Pons[67]. SRLIS, a semi-structured interview protocol focused on "hypothetical learning contexts"[98] (p. 284) based on research with K-12 students comprises 14 themes[63,67], including *self-evaluation*, *organizing and transforming, goal-setting and planning, seeking information, keeping records and monitoring, environmental structuring, self-consequences, rehearsing and memorizing, seeking social assistance* (peers, teachers, adults), and *reviewing records* (notes, books, tests).

Prior research has explored connections between SRL and FTP at length, such as the findings that suggest a student's FTP can be motivational for adopting SRL strategies[4,13,60,102]. The model created by Miller and Brickman[4] focuses on the fact that a distal future goal in turn motivates the creation of distal sub-goals, which are motivational for proximal self-regulation. Another model by Deci and Ryan[138] shows that FTP is linked with self-regulation, with a focus on the fact that the "journey" is more important than the future end result. This suggests that a connection exists between SRL and FTP, rather than FTP serving as simply general motivation for students. More recently, Simons, Dewitte, and Lens[139] discussed that PI may be a key aspect of student motivation, and the connection between SRL, PI, and FTP has been described in previous literature[59]. While theory and literature has shown connections exist between SRL and FTP, including quantitative studies of engineering students[29,60], research is lacking to describe the nature of these connections. This pilot study will begin looking qualitatively at why and how engineering students connect their views of the future to the self-regulation of their learning in the present.

3.4 Research Purpose

This research is a pilot of a piece of a larger, mixed methods project which seeks to understand the connection between engineering students' FTP and their SRL strategy use through investigating the sub-questions as outlined below:

1) What SRL strategies do IE undergraduates use?
2) How do students' FTP attributes relate to their use of SRL strategies?
3) How do the SRL strategies among different FTP types compare?
4) What are the connections between SRL and FTP?

3.5 Methods

This project is a pilot of a multi-phase mixed methods sequential explanatory study. In Phase I (quantitative), a survey was implemented in an IE course and a cluster analysis was run on the survey responses to select the participants for the second, qualitative phase. In Phase II (qualitative), we piloted the use of a semi-structured protocol to interview four students, with the goal of selecting at least one from each FTP type as determined through the cluster analysis in Phase I, and analyzed SRL strategy use and the connections between SRL and FTP. While we analyzed interviews in this pilot for these four participants, we collected other pieces of qualitative data, which will be utilized for triangulation in future case study and related work.

3.5.1 Phase I

A quantitative survey was distributed to students enrolled in a sophomore level IE seminar course in the fall at a southeastern land grant, four-year university at the end of the semester (n=118). Students were a mix of sophomores and juniors. Students received course credit for completing the survey in Phase I, and a final letter grade was assigned for this course. These students participated in a larger study as outlined in another paper[86], which included attendance at an intervention focused on using SRL strategies and writing reflections about their SRL strategy use. While the intervention may have impacted student self-report of their SRL strategy use, two benefits occurred: improved rapport with the researcher, who provided the intervention, and a greater fluency of SRL strategies in the reflections and interviews.

The survey distributed at the end of semester included four sections with 86 items. Some items were adapted to be applicable to an engineering course from the Motivated Strategies for Learning Questionnaire (MSLQ)[74,100]. Other survey items were written in three sections[136]: a 13 item goal orientation section, a 28 item FTP section, and 16 items on task and course specific problem-solving self-efficacy[140]. The MSLQ[64,100,141] has been well-documented, and the MSLQ and MAE survey[38] have both been tested for validity and reliability. Only the 28 items from the FTP section of the end of semester survey were included in a cluster analysis (see Appendix D) due to the research questions for this pilot study. The items in Appendix D are labeled by factor: future on present (items that describe how future goals of the student influences present actions), PI (items that describe relevance of a task), and perceptions of the future (items that describe views of the future).

We conducted a k-means cluster analysis[142] utilizing a statistical software environment[143] in R[144]. When running a cluster analysis on a survey, the k-means variety utilizes scores of survey factors to form homogeneous subgroups from the data by maximizing variance between clusters and also minimizing variance within the clusters. Promax rotation was utilized to adjust for the fact that some of the factors in our survey were correlated; more details about correlation among factors and utilizing rotation in a cluster analysis may be found in the literature[145,146].

3.5.2 Phase II

In the following spring, students enrolled in the same sophomore level IE course the previous fall were recruited to participate in semi-structured interviews (see Appendix E) addressing their views of the future and how they regulate their learning. Four students volunteered for the interviews, and each student was given a $20 Amazon card as incentive for participating. Interviews were transcribed, and the text was analyzed with RQDA using directed content analysis[147], with both *a priori* coding and emergent themes. *A priori* themes used in the analysis are from previous uses of this protocol in regards to the FTP sections[50], as well as the Zimmerman and Martinez-Pons[63,67] framework in regards to SRL in previous work[86]. Themes about the connections between these students' FTP and SRL were allowed to emerge from the data.

The Q^3 quality assurance framework by Walther, Sochacka, and Kellam[104] was utilized to examine the validity and reliability of the qualitative methods in Phase II. Previous work on FTP and SRL were referenced, and experts in the field were contacted to ensure *theoretical and procedural validity* of this project. A thorough description of the data collection procedures was collected, and descriptive memos were taken throughout the research process during data analysis, supporting *pragmatic and procedural validity*. Multiple researchers, including an engineering undergraduate, conducted the data analysis in Phase II to ensure *reliability* and *communicative* and *pragmatic validity*. The interview protocol has been reviewed by undergraduate engineering students to check for the correct interpretation of the questions and to ensure that the answers aligned with our research objectives, supporting *communicative validity* of the questions. Additional support of *communicative validity* includes selection of representative quotes from each interview.

3.6 Results and Discussion

3.6.1 Phase I

To select students for the qualitative phase, a cluster analysis around the FTP variables was completed. The items and factors (perceptions of the future, future on present, and PI) of each item are listed in Appendix D. Three clusters were expected due to previous research from a k-means cluster analysis and follow-up qualitative work[36,49]. These clusters are described below:

1) low future scores, low future on present scores, and high PI scores
2) medium future scores, high future on present scores, and low PI scores
3) high future scores, high future on present scores, and high PI scores

A dataset was created with the averages of these three factors, and the number of clusters appropriate was determined utilizing a plot of the variance, which is included in Appendix F. From the plot of variance, two, three, four, or five clusters appear to be a good fit. Due to the pilot nature of this work and as the purpose of the cluster analysis was for participant selection, rather than analysis of the participants' FTP, we selected k=3 as our final clustering as three clusters (see Appendix G) of FTP characteristics were found in our prior research[36]. The average scores noted for each cluster by FTP factor appear to match this previous work: Cluster 1 has low future perceptions and low future on present scores, Cluster 2 has medium scores, and Cluster 3 has high scores for all three factors. This is shown in Table 3.1. Scores of the interview participants in Phase II are included in Table 3.2.

Table 3.1: Average scores for each of the three clusters according to FTP factor

Cluster	N	Perceptions of the Future	Perceived Instrumentality	Future on Present
1	28	3.90	3.61	2.04
2	52	3.52	3.50	3.30
3	38	4.09	4.36	4.26

Table 3.2: Scores for pilot study participants in Phase II according to FTP factor

Participant	Cluster	Perceptions of the Future	Perceived Instrumentality	Future on Present
Amy	1	3.29	4.50	2.0
Blake	3	4.43	4.33	4.0
Claire	1	4.57	3.17	2.5
Daisy	2	4.00	3.67	3.5

3.6.2 Phase II

The following section details the FTP, SRL strategy use, and connections between FTP and SRL of four engineering students enrolled in a sophomore level IE course based on the interview protocol attached in Appendix B. A codebook for analyzing FTP is included in Appendix H, with sample quotes from study participants for each code. Similarly, the SRL categories described by each participant are listed in Appendix I. Below we describe the FTP, SRL, and the connections between the two for each individual case study participant. All names shown for the four individuals are pseudonyms.

Case 1: Amy

Amy is a Caucasian, female second-year engineering student in her third year at the institution. She declared her engineering discipline in the fall. Unlike the other participants, she originally declared biology as her major but switched to engineering due to the high value she placed on the work of engineers after seeing what her friends were doing in their courses and seeing what types of jobs she could have after graduation. She chose her engineering discipline in a “pragmatic” way—IE would allow her to graduate in a timely manner, and she did not like other disciplines such as electrical engineering.

FTP

Amy’s core attributes follow: an ill-defined and open view of the future, high PI for her IE and all other coursework, and an overall positive time attitude. Amy’s description of the distant future was vague and ill-structured. She mentioned many desired futures, such as earning an MBA, acting as a lead engineer, working in industry, and engineering in a startup company. She described her desired future best as “happy” and “well-off.” While her possible future appeared open, Amy was able to articulate in detail short-term goals, such as playing every intramural sport at the university in a single school year, and how she planned to obtain them. Amy fits into cluster 1, as her goals do not extend far into the future.

While Amy was not clear about the job she definitely wants, she was very clear about characteristics, such as no manual labor and “use hands and brains,” again, common for students in cluster 1. She also mentioned many feared possible selves in her career, which is common among cluster 1 students; for example, she fears being overly involved and "not feel[ing] like I'm continually going everywhere." These details again support that Amy may be transitioning between clusters.

Amy has a high PI but low future on present, which match her survey scores and is consistent with cluster 1. She sees many things she is doing now as relevant and instrumental to the future (i.e. her Public Speaking course), but she does not have future goals that help her decide what is important in the present; she believes everything she is learning may be useful: "…the whole world is your oyster when you're an engineer. They give you all the tools and then you just get to do stuff."

SRL

Amy described a strong use of SRL strategies (Appendix I). Some of her SRL strategies overlapped with her goal of succeeding during finals week: managing her time, being organized with notes, and getting plenty of sleep. Amy frequently mentioned getting enough sleep and attending class (s*tudy environment*), and she explained how she utilizes a summary sheet to study (*organizing and transforming)*. Finally, Amy mentions that in studying, it is important to "know yourself," including using focus and perseverance (*self-evaluation)*. Amy explained that studying is the same in engineering and non-engineering but was able to articulate the differences in particular courses, such as coding versus memorization-based engineering content.

FTP and SRL Connections

Amy's connections between her FTP and SRL appear within her PI of her current tasks and within her goal-setting for her courses and her short term life and career goals. She spoke of how many courses are important to her future. In particular, she mentioned that she adopted her study skill set after attending workshops through the learning center on campus due to how valuable she thought the new skills could be on her success in her coursework. Her short term goals, such as working at an internship related to engineering, influenced a much shorter term goal of achieving a high GPA. In this case, her longer, short-term goal influenced her adoption of a more proximal short-term goal.

Her self-regulation was also influenced by her goals, primarily her distal goal of happiness. Her proximal goal of succeeding during finals week influenced her self-regulation while studying for her finals. Additionally, her drive to experience so many things during her time at the university, such as playing all intramural sports, caused her to utilize time management and other SRL techniques to best maximize the use of her time. Her strong use of SRL strategies connects to her high PI of all coursework, including engineering and non-engineering courses, and her goals of having a good GPA and graduating. Overall, Amy mentioned that "success is what you want it to be.” Her SRL habits are a means to an end: “…me studying gets me good grades which will get me into either a good grad school or a good job. They're pushing me along” and her set of goals are mapped out in Figure 3.1.

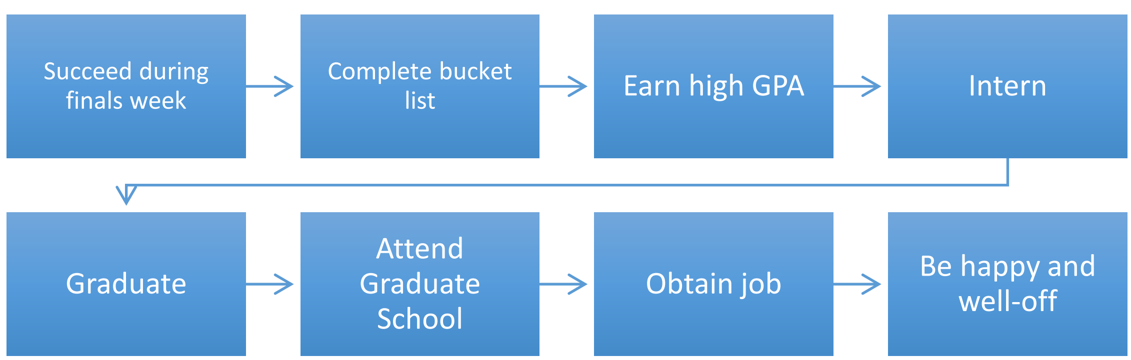


Figure 3.1: Amy’s timeline of her proximal sub-goals and distal future goal relating her FTP and SRL

Case 2: Blake

Blake is an undergraduate Caucasian, male who spent a few years in the military before returning to the university. He enrolled in general engineering and selected IE due to the “efficiency” focus of the courses. He felt that the military lacked many aspects of efficiency and disclosed wanting to be able to improve processes in a company. Blake is not a typical male sophomore due to his past work experience and age.

FTP

Blake fits into cluster 3 with a long FTP, well-defined distal goal, explicit path of sub-goals, detailed desired future career characteristics, high PI in courses he feel are relevant to his future, and a positive time axis. During the interview with Blake, he clearly described a well-defined, long-term future goal: becoming chief operating officer (COO), a proximal sub-goal which was created due to his distal future goal of being financially stable. Figure 3 depicts his outline of sub-goals leading to this distal future goal with an end point of retirement, which Blake also described as a time when he hopes to be financially stable.

Blake described a very high PI for engineering, mathematics, physics, and other related courses to his future career goals: “When as in IE, you can do whatever you want, really. There are just so many applicable areas that you can use for a process improvement." Blake said that general education courses are irrelevant, but he showed a high level of PI when describing his work in daily life, such as efficiency while driving.

A key aspect about Blake was the impact of his past on his current state and future goals, and he described several ways his future goals are impacting his present. His previous military experience has helped him create a well-defined career path, and he described an example of a job characteristic he values due to this past experiences: “I had my time wasted by inefficient management for years. It really gave me appreciation of efficient management. It’s kind of what industrial engineering is all about.”

SRL

Blake’s self-regulatory study behaviors stemmed primarily from his experience in the military and due to his future goals. Specifically, Blake mentioned on multiple occasions that repetition is important in learning information (*rehearsing and memorizing, organizing and transforming*), and he discussed attending and engaging in class (*keeping records, seeking information*). Overall, Blake is a perseverant and reflective learner (*self-evaluating*); he described differences in studying between classes, and in particular that the memorization in IE is the same as other classes. While Blake self-regulated in his current courses, especially if he felt the material will be necessary in the future, he was clear that he felt you must be motivated to learn to figure out how to appropriately study and learn the material in a course.

FTP and SRL Connections

Blake stressed the importance of reiterating material to learn it and the relevance of the material and his motivation in the course played a huge part in whether he self-regulated in a course. His perception about the importance of material to his future and if he felt the future depended on knowing the material altered how he studied for courses, as shown in this quote:

> “…I would say that using study skills is important but… it’s just hard for me to look at… some of these questions …and say, ‘This, this is definitely going to decide my future. Memorizing is going to be something that makes or breaks my career.’ I can never get myself to be motivated enough to learn with that mindset because I just know that it’s not true.” -Blake

Blake described self-regulating differently in relevant versus general education courses: "I don’t use the same study skills because the classes [non-engineering] are stupid. That’s really how I felt about it the entire time." However, his past experiences appeared to have a large impact on his SRL, and the goals he set for himself created the motivation for him to self-regulate in his courses to achieve the path of proximal sub-goals set up to reach his distal future goal of financial stability. His future goals are impacting how he regulates his studying now and have helped him create a path of sub-goals, which additionally motivate him to be successful.

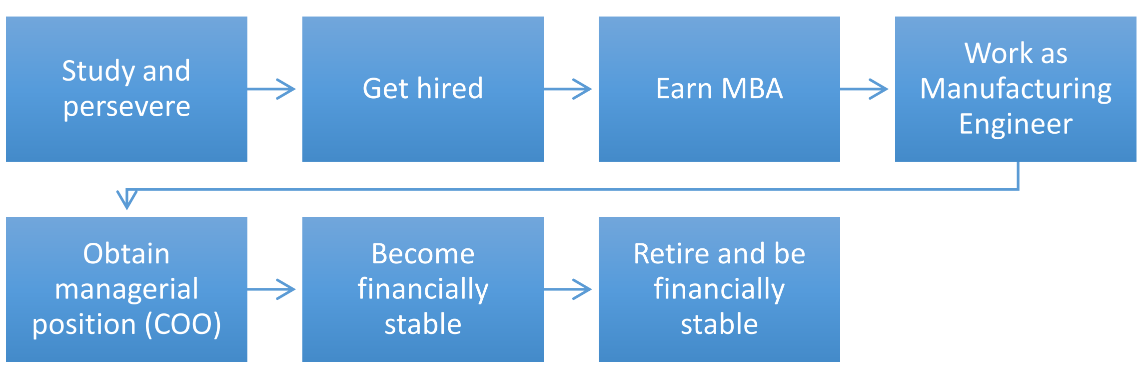


Figure 3.2: Blake's well-defined set of goals that reach 10+ years into the future, relating his FTP and SRL His well-defined distal goal supports his path of proximal sub-goals, which reinforce his SRL.

Case 3: Claire

Claire is a second-year, Caucasian, female IE major at the university who started in general engineering and selected IE after a year classified as a chemical engineering (ChemE) major.

FTP

Claire has a positive outlook of the future, a high PI, and an extremely ill-defined view of the future: "I just want to be able to know all my different options that industrial engineering offers, to see exactly what I want to do in two years." Claire's main goals are to obtain a good job that allows her to travel and be happy. Her mother had a large impact on her work goals, and she mentioned working as a professor as an avoided future due to her mom's experience as a teacher. She aims to "always improv[e]" her position and knowledge, just like her mom.

Claire has a high PI for all of her courses except general education courses, in which her motivation was lowered. She said "I learned so much worse because I'm just like not interested in the class, so I don't really want to learn the material…," but that she was lucky to have a [language] minor so that the majority of her general education requirements were filled by more relevant courses. Additionally, one key reason for her switch in engineering discipline was she found IE material more relevant than ChemE.

Besides course material, she described relationship building, along with problem-solving, leading, networking, and communication as important, which she is learning in school: “You're going to be working with different engineers, you're going to be working with chemical engineers, mechanical, anything electrical, and you need to be able to, like, express your views.”

Claire fits in cluster 1; her experience with the major limited the characteristics she could describe for her future job. The goals she described were primarily short-term and ill-defined. Figure 3.3 shows Claire’s goal timeline, along with her distal future goals of being happy and progressing in her career. Her positive, but ill-defined, view of the future is captured in this quote:

> “I guess just [actively striving for] experience right now. I'm looking to shadow some process or some field engineers in manufacturing through different companies this summer, as well as working at [company]. I’m just trying to get as much experience as possible, because I just want to be able to know all my different options that industrial engineering offers, to see exactly what I want to do in two years.”

SRL

Claire described typical student study habits (Appendix I) of taking notes in class, reviewing slides, and rewriting material (*record keeping and monitoring*, *reviewing records*, *rehearsing and memorizing)*, and the other self-regulatory habits she mentioned include *seeking social assistance*, such as studying in groups, and adapting her study environment (*structuring environment*). When talking about working with professors, she focused on the future impact, something she learned from her mother, a variation not commonly seen with *seeking social assistance*. She explained that the better you know your professors, the better you are able to determine what information in class is important.

Claire mentioned selecting the main ideas of material, *organizing and transforming material*, as "efficient" because students "don't have to study as much material because you know exactly … and you can study the main points more." However, Claire described studying as "personal" and different between people rather than courses. She also viewed success as meeting her own expectations, including success in studying. Overall, Claire described studying as putting in time, and she did not describe major differences between how to prepare for engineering and non-engineering courses. She described studying for dissimilar courses as different, such as memorizing versus learning a process, and that studying depends on the material and not the subject: "I think engineering is mostly ... problem solving. Whereas [language] has no problems, it's just knowing the material."

FTP and SRL Connections

Claire described the short-term future, specifically job interviews, when asked how she developed the ideas of what was important that she is learning. She viewed studying and study skills as instrumental for her future, and her view of wanting success in the future impacts her study habits in the present: “I think just the fact that I find it interesting and that I want to retain that information, I might study a lot differently from someone who doesn't really care…. I'm hoping to use it in the future so I'm studying differently because of that.”

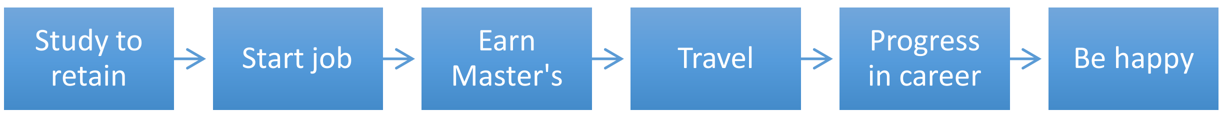


Figure 3.3: Claire’s timeline of her ill-defined distal goal and her short-term sub-goals. Claire has an extremely open view of the future but an ill-defined set of proximal sub-goals that do not reach far into the future.

Case 4: Daisy

Daisy is an international student who came to the United States to study engineering at our institution. While she is a second-year student in IE, her international roots may have an impact on her FTP and SRL habits. However, her interview provided insight into an international perspective and fourth view of the possible connections between FTP and SRL.

FTP

Daisy fits in cluster 2, with a conflicting ideal and realistic view of the future and low PI. She discussed becoming an engineer and obtaining an MS degree in America. However, on multiple occasions, Daisy wistfully spoke of her goals of opening a bakery in her home country. While these goals may appear long term, she was very clear that she plans only over the short term, which may be caused by her home culture but also could be caused by characteristics of her cluster type: “Like how I will think of a plan too much, it doesn't really help me, so I will just try to have a plan for the near future, and make that plan be safe, but don't get fixed on something and then realize I didn't want to do that.”

While she is conflicted about these two goals and which to pursue, she is clear that she does have one distal goal: to be “happy.” When she spoke of being happy, she discussed a certain lifestyle, which may have caused her to be open in her career planning. This distal future goal motivated her to form the proximal sub-goals of pursuing higher degrees, as she believes that a higher degree will allow for a better job which will translate into a higher level of happiness. Additionally, she has a low PI for her coursework, and she labeled herself as “lazy” in her courses. Daisy’s timeline of her future goals is in Figure 3.4. Of the four students, she has the least amount of goals and the lowest PI, but her goals are well-defined, though conflicting, all characteristics of a cluster 2 student.

SRL

Daisy self-reported using SRL strategies listed in Appendix I. In particular, she mentioned multiple times working problems, as many undergraduate engineering students do, but most interestingly making sure to knowing the “why,” a very self-evaluative feature of self-regulation. Daisy mentioned that study skills are context and person dependent by saying, “I mean it will change from math to literature, and stuff like that. It's like industrial engineering, there's a lot of different classes, so I think it doesn't really, it's specific.” Daisy dislikes general education courses and spoke of being “lazy” in classes she does not like. She self-reported her studying as very limited but mentioned that she earns good grades. While “lazy,” Daisy is particularly self-aware and is clear about how she does and does not study, so she was able to explain her SRL strategy use. She even went as far as to say "I don't like study skills."

FTP and SRL Connections

Though Daisy self-labeled herself as “lazy,” she did describe a connection between her future goals, such as a high GPA and being happy, and the regulation of her learning. However, the goals she connects this regulation to are very short term: “If I have a goal to get a graduate degree, it affects that I work to get good grades besides understanding, so I try to do what I have to do, even if that would not help me to get better understanding, just because it gets me better grades, and I want to get that.”

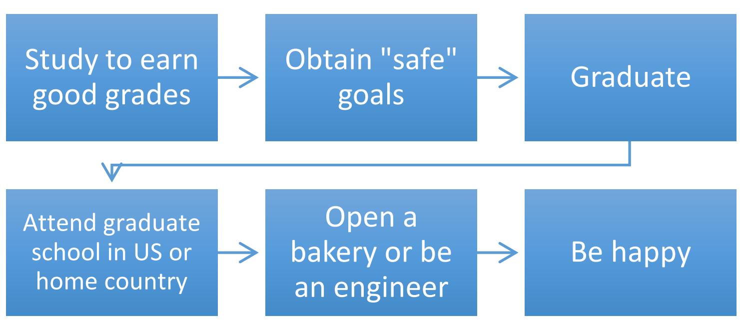


Figure 3.4: Daisy’s timeline of her proximal and distal goals relating her FTP and SRL. Daisy sets very short-term goals and has two conflicting future goals: an ideal goal of being a baker in her home country and a realistic goal of becoming an engineer.

3.7 Conclusions, Limitations, and Future Work

The goal of piloting the FTP and SRL interview protocol was met and the methodology was shown to be effective for collecting and analyzing data on FTP, SRL, and their connections. The cluster analysis accounted for a high level of variance (81%); however, while the interview data triangulated with the survey data, the FTP survey items may not completely measure the clusters. The qualitative piece was useful in observing and analyzing a more complete picture of the FTP of each student to compliment the quantitative piece of the study. In addition, this also yielded an overview of the SRL use in engineering and non-engineering courses, and helped to begin building connections between FTP and SRL. However, there are still some questions left unanswered and more questions about the connections have been generated. Other qualitative work may be useful in guiding the building our knowledge of FTP, SRL, and the connections between the two for the engineering undergraduate population.

Some themes persisted between cases and may highlight FTP and SRL connections in future work. Both students in cluster 1, Amy and Claire, defined success as meeting their own expectations, a theme which may persist among students in this cluster; additionally, both of these students felt material outside of their major coursework may be relevant to their future and saw a difference between studying for different kinds of coursework, specifically in and out of major. Additionally, the four students self-reported using a variety of SRL strategies, which can also be seen in a previous study[86]. Finally, when a participant reported a high level of PI in a course, they also reported a high variety of self-regulatory strategies.

For future SRL and FTP work, more sources of data should be collected for a multiple case study for triangulation. A cross-case analysis would be useful in the future, for which more sources of data will be needed. While the data showed SRL strategies, FTP, and some connections between the two, more data should be collected and analyzed about how these students are regulating their learning, especially in their engineering courses. One such source could be periodic reflections during the course on their study strategies. Also, more interviews should be conducted to connect the pieces between how and why students are self-regulating and the views of their futures. A future survey addressing the cluster types may highlight common themes between student FTPs and how they regulate their learning in the present.

Overall, this study is limited by the nature of self-reported data. While this is common, future work should aim to triangulate the quantitative and qualitative data with additional information on actual student SRL strategies. This project helped to validate the motivation survey our research group has developed by triangulating the self-reported FTP items on the survey with the qualitative FTP interview. Bias was a concern since the researcher who hosted the workshop about SRL strategies was also the interviewer; therefore, a second researcher was present at each interview to corroborate the data, review the notes and transcript, and to read the analysis and results. The familiarity with the researcher helped with rapport during the interview. The attendance at the workshop may have biased the results of the self-report of SRL strategies, but this limitation was offset by the benefit of providing the students with language about SRL with which they could verbalize their strategy use. This is important as prior research showed that students have incomplete or “naïve”[61] models of what SRL entails[148].

Several connections were seen by piloting the interview protocol assessing FTP, SRL, and the connections between the two for undergraduate engineering students. However, while not the focus of this work, future work may want to look at how students define success in their undergraduate engineering programs. A future interview with students should be developed which focuses on goal-setting to paint a clearer path of student goals and views of the future. This protocol should also address how and why engineering students set goals and create views of their possible future. Other FTP literature should be incorporated to highlight these paths, such as Raynor’s work on achievement motivation[32,58,149].

3.8 Implications for Practice

Based on our participants’ responses regarding how their perceptions of the future affect their SRL strategy use, practitioners should work to build career awareness, general education importance, and goal-setting agendas into their curricula. To see the value in the work in major and non-major courses, students need to be able to map out the relevancy of the material to their futures. If students are more aware of what types of jobs are available in their major, and the nature of those jobs, students may have a higher PI related to their coursework and may be able to connect the current task at hand to their future. Additionally, if students can see how general education courses are important to other current, valued coursework or directly to future valued roles, students may engage in this material in a more regulated manner. Finally, helping students build goals in their field, including a distal future goal and proximal sub-goals mapping to this overarching goal, will help students regulate their learning on current tasks that they see as valuable to this path. Curricula that focus on careers and goal-setting will help students regulate their learning in their coursework as they will see a higher relevancy to their future.

CHAPTER FOUR

4. Cluster Analysis Methods and Future Time Perspective Profiles of Second-Year Engineering Students in a Major-Required Course

4.1 Introduction

The primary purpose of this chapter is to identify homogeneous groups of second-year engineering undergraduates in a major-required course in terms of their motivations and attitudes based on results from two types of cluster analyses that were conducted on survey data. This study is part of a larger project seeking to understand the connection between the motivation and attitudes of undergraduate engineering majors and their learning, and the homogenous groups will be utilized to select participants in Chapter 5. One specific aspect of motivation, Future Time Perspective (FTP)[150], has been shown to have a connection to student strategies and how they approach learning in the present[3,60,151]. It is often difficult to select appropriate analysis methods for such quantitative data, and there is a lack of literature for engineering educators comparing types of quantitative analytic methods. Thus the secondary purpose of this paper is to fill this gap by discussing multiple types of cluster analysis (CA) techniques, selecting the best clustering method and solution, and then use the clustering results to discuss quantitative domain- and context-specific differences between the FTPs of second-year undergraduate engineering majors. The research question for this chapter is: *What are the motivational (FTP) characterizations of undergraduate engineering majors within the context of a major-required course?*

4.2 Background

4.2.1 Cluster analysis

CA is the "art of finding groups in data"[152] (p. 1) and is the best method for this research due to its "person-centered" approach, as it allows a "one-to-many" look at dimensions[153] (p. 901). To select a CA method for a study, three questions should be considered[154]: Which similarity/dissimilarity measure (measure of distance between data points) is appropriate? How should the data be normalized? How should domain knowledge (theory and input parameters) be utilized when clustering data? Additionally, external (fit of clustering solution compared to theory), internal (fit of the clustering solution compared to the data), and relative (fit of multiple clustering solutions) quality should be considered[155].

Multiple types of distance measurements between data points exist, such as Manhattan and Euclidean which are special cases of a metric used for vectors (Minkowski). Some measurements work best with specific types of data (e.g., Manhattan is primarily used for binary data)[152]. The Euclidean distance, or a variation of it, is the most common, and the formula for this distance measurement between data points is the square root of the sum of squares of differences between each set of data points[152]. This similarity measure is utilized in most CA methods. Relatedly, standardization helps strip "units" from the data and helps relieve issues from outliers by reducing the influence of any singular data point[152]. In education research, z-scores are traditionally used for easier comparisons by adjusting data that have different means or standard deviations[156]. The original data is adjusted from a $n \times p$ matrix of values x to a new set of z-scores; these scores are computed by subtracting the mean value of the associated column, f, from each data point x_{if} and then dividing by the mean absolute value of the associated column, f. The new matrix of z-scores (z_{if}) is then used for analysis rather than the original data (x_{if}). Similarly, if data is standardized, z would replace x in the Euclidean distance formula.

Figure 4.1 depicts an overview of CA methods available for selection and breaks CA into two categories: hierarchical and partitional[154]. The available knowledge within a domain is also important when considering the appropriate CA technique. Hierarchical methods are considered most useful when there is little theory to frame the research[157,158], whereas partitional methods are methodologically sound in such cases because robust methods may be used to select the appropriate number of clusters[155,159,160].

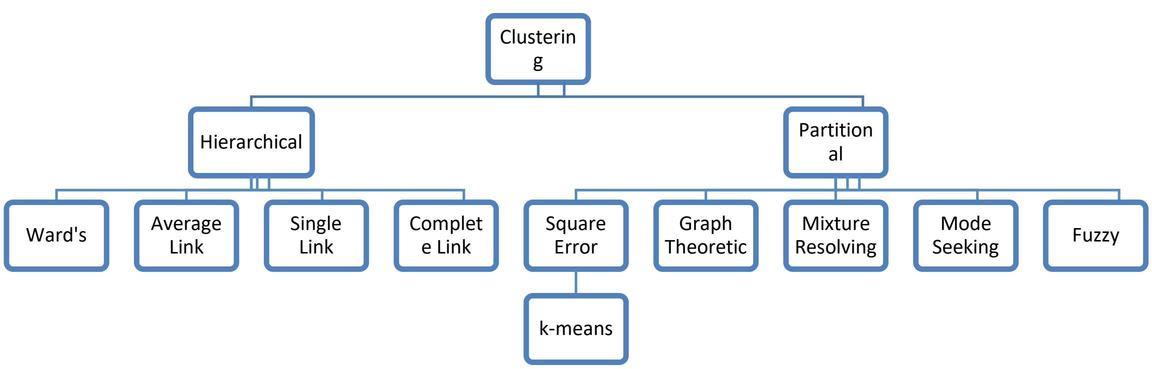


Figure 4.1: A taxonomy of clustering approaches[154]

Hierarchical clustering, also called *agglomerative clustering* due to its nature of combining clusters, is an iterative process beginning with N clusters, with each cluster made of a single point. Close clusters are iteratively combined at each step, repeating until all data points are in a single cluster. *Divisive* methods may also be considered hierarchical clustering, as they also give the user a "hierarchy" of a set of possible clusters from 1 to N, but they begin with a single cluster that splits until a total of N clusters is reached. Researchers can choose the most appropriate clustering solution using the dendrogram, or tree, produced. The primary concern to researchers when using hierarchical clustering algorithms is that they are sensitive to outliers and noise, as they do not reconsider a data point once it is placed into a cluster[161]. Additionally, hierarchical CA can be computationally expensive, but most statistical software can assist with standardization and account for outliers, making the computations easier and potentially solving common issues with hierarchical clustering methods. Hierarchical clustering

Table 4.1: Common hierarchical clustering algorithms, including associated distance measurement, strengths, and weaknesses[152,163]

Clustering Algorithm	Distance Measurement	Algorithm Information
Ward's minimum variance method	Uses the squared Euclidean distance	Sensitive to outliers; tends towards consistently sized clusters
Single linkage (termed "nearest neighbor")	Uses minimum distance between a participant in one cluster from another participant in the second cluster	Does not constrain clusters to compact, round shapes; known for a "chaining effect"
Complete linkage (termed "furthest neighbor")	Measures distance between two clusters as the maximum distance	Known for distorting outliers due to its tendency toward evenly distributed, similar, round clusters
Average linkage	Uses the average distance between pairs of observations	Created as a compromise between single and complete; biased in producing clusters with similar variance and size

algorithms differ in terms of their measurement of distance, with some of the most commonly used in statistical software which utilize different distance measurements being Ward's minimum variance method, single linkage, complete linkage, and average linkage[152,154,162]. Table 4.1 depicts the distance measurement used and the key differences between the different common hierarchical clustering algorithms.

Partitional clustering methods divide data points into groups with a fixed number of clusters provided by the user. As noted by Kaufman and Rousseeuw, "a partitioning method tries to select the best clustering with k groups, which is not the goal of a hierarchical method"[152] (p. 44). The *k-means clustering algorithm* is a partitioning method that forces each data point into one, and only one, cluster. This clustering algorithm is the most popular type due to ease of use, efficiency, empirical success, and low computational cost[155]. In fact, many extensions of k-means have been created; though these are not as popular, they often allow for additional parameters such as "fuzzy" assignment (allowing data to be assigned to more than one cluster) or minimum cluster sizes[155,164,165]. Other, less popular and less robust partitional methods are listed in Figure 4.1[152,154,155,166]. The k-means CA is considered the best of the group as it has low computational cost and is easy to implement[154]. The k-means CA utilizes the Euclidean distance to determine the number of clusters and compute the partitions and minimizes the within cluster square error or sum of squared error (SSE)[167] by assigning each point to the smallest value of the SSE.

One way to select the number of clusters (k), which the researcher must identify to run a k-means CA, is to create a plot with the number of clusters on the x-axis and the within group sums of squares (wss), a score representing how spread apart data points are within a single cluster, on the y-axis. The appropriate number of clusters is selected by looking for the change in slope or bend in the plot, representing a significant decrease in the wss, which is similar to looking at a scree plot in exploratory factor analysis (EFA)[160]. R uses an algorithm which minimizes the sum of squares of the points/observations of the k groups to their k-group centers to find k-means clusters[168]. With this method, "kmeans()" randomly chooses the k centers of each group, which can cause variation in the output. However, "Set.seed()" can be used to reproduce the same output, an important feature for recreating the same results. This algorithm is sensitive to outliers as it forces them into clusters, despite their distance from centroids, which may alter the shape of the clusters[161,169]; however, the algorithm benefits from reconsidering these data points at each iteration, unlike in hierarchical clustering algorithms.

Other quality concerns, such as choosing an appropriate method based on the number of participants in the data set, should be considered when selecting a CA method. A minimum sample size of 2^k participants, where k is the number of variables, or a stronger minimum of $5*2^k$ cases has been suggested[170], but there is not always consensus on this number [171]. The literature shows that hierarchical analysis is regarded as appropriate for smaller data sets (from tens to hundreds), while partitional methods (such as k-means) are best fit for larger data sets (hundreds to thousands and tens of thousands)[158]. No matter which method is selected, the quality of the clusters should be considered. For this study, external, internal, and relative quality[155] will be considered: the clusters will be compared to theory and experts will review CA method selection (external); the CA will be analyzed for goodness of fit measures (such as wss) and "rag bags" (a cluster made of extraneous or outlying participants)[172] (internal); and multiple algorithms will be assessed based on the requirements, strengths, and weaknesses of each algorithm (relative)[143,154,158,160,173]. Algorithms that appear to be a strong match for the data set will be presented and the strongest clustering solution will be selected.

4.2.2 Cluster Analysis of Student Motivation

Several studies of multiple populations have utilized CA to analyze and characterize student motivation and learning[7,29,153]. Other studies have utilized k-means CA to find a clustering solution for the Future Time Perspective (FTP)[60,150] of engineering undergraduate students. In particular, some studies have utilized the Motivation and Attitudes in Engineering (MAE) survey (described in Chapter 2 and included in Appendix J) as data when conducting a k-means CA to group undergraduate engineers[36,39,40] and have discussed results in relation to the cone model from Chapter 2, in which three characteristics future views of undergraduate engineers have been shown: sugar students with a clear future view; waffle with conflicting ideal and realistic futures; and cake with open views of the future. When considering multiple motivation constructs (FTP, Expectancy, Problem-solving Self-efficacy), four clusters were found using k-means to group mechanical engineering (ME) and biomedical engineering (BME) students in a major-specific course (Kirn, 2014). Other examples have focused on three FTP constructs: Perceptions of the Future (F), Perceived Instrumentality (PI), and Effects of the Future on the Present (FoP). In Chapter 3 of this dissertation, a mixed methods study was conducted which included a k-means CA. The study focused on industrial engineering (IE) sophomores enrolled in an introductory, required IE course, who clustered into three FTP clusters for use in participant selection[40]. One group had all high average scores; another had lower average scores than the first; and a third group had a low average FoP score. A similar study researched freshmen engineering students enrolled in a first-year engineering course showed a three FTP type clustering solution with similar values[39]: a group with comparatively high FTP scores, a group with comparatively low FTP scores, and a final group with high PI, high F, and low FoP scores. The main conclusion from these previous studies is the difference between the cluster groups (as described by cone types in Chapter 2): one cluster group generally has high scores for all three constructs (sugar) as these students have a well-defined, positive view of the future; a second group has a lower PI score than the other two groups (and overall lower scores than group 1) (waffle) due to conflicting future views; and a third group has a low FoP score (cake) as these students are unable to see far into the future. From these past cluster analyses of the FTPs of engineering students, three group cluster solutions and associated FTP cone, as described in Chapter 2, are expected with the following scores:

Group 1: high F, PI, and FoP scores (sugar)

Group 2: lower F, PI, FoP scores than Group 1 and a low PI score overall (waffle)

Group 3: lower future scores, high PI scores, and overall low FoP scores (cake)

While k-means has primarily been used to identify homogeneous groups of engineering students in terms of their motivation and/or learning attributes, this chapter seeks to select the most appropriate CA method and will compare both hierarchical and partitional methods. The chapter specifically includes the solutions from the Ward's and k-means clustering algorithm to select the most fitting cluster solution. The results will be used for participant selection in future chapters.

4.3 Methods

4.3.1 Motivation and Attitudes in Engineering Survey

The Motivation and Attitudes in Engineering (MAE) survey[38,174] (see **Appendix J** and described below) used in this chapter consisted of 5 sections with 86 items related to goal orientation[42], FTP and Expectancy (E), task specific metacognition, problem-solving self-efficacy[140], and demographic information. This paper presents a CA of the domain- and context-specific Future Time Perspective (FTP) items and thus utilizes the FTP and Expectancy section. The FTP items contain five theoretical factors: Perceived Instrumentality (PI), Perceptions of the Future (F), Future on Present (FoP), Value (V), and Connectedness (C). The Value and Connectedness items, adapted from Husman and Shell[26,150], were added based on previous qualitative FTP work[36,39,174]. Other items were original (based on findings from prior qualitative studies[36,39,174]), and some were adapted from the Motivated Strategies for Learning Questionnaire (MSLQ)[74,100], which is well-documented and found to be valid for a similar population[38]. Note, one of the C items ("It is important to have goals for where one wants to be in five or ten years.") was repeated during implementation and the second copy of this item was removed from the survey data for analysis.

Items in the FTP and E section were 7-point Likert-type items with anchors "0-Strongly Disagree" and "6-Strongly Agree"[175]. An anchored scale makes testing, such as EFA, more valid, and allows for an easier interpretation of numeric responses[176]. E items for this population are typically high and generally rank the same on a Likert scale as this group of students is seen to have high hopes in their engineering coursework[36], and E will not be included as it does not help to differentiate students in the CA. Additionally, this research is focused on domain-specific (engineering) and context-specific (enrolled course) FTP. Three of the factors, PI, F, FoP, are domain-specific, as they refer to engineering or ask the student to reflect on an engineering course[30]. The V and C factors are domain-general. The item specifications and construct list are included in **Appendix K**. More about the MAE survey and the difference between domain-specific and domain-general FTP is described in Chapter 2.

4.3.2 Participants

The MAE survey was distributed in class and submitted online by students enrolled in one section of a sophomore-level materials science and engineering (MSE) course required for industrial engineering (IE), BME, and ME undergraduates at a four-year, land grant institution in the southeast (n=97). Additionally, the survey was completed in one section of a required, sophomore-level IE course (n=205) during the same semester. Both sets of students received class credit for completing the survey during class time.

While this study focuses on an MSE course, the sample size for that population is less than 100 (N=97), which is not ideal for an EFA. A second sample (N=205), a set of IE second-year students who completed the MAE survey in the same fall, was compared to the MSE sample. If the samples were shown to have no difference statistically, we would aggregate our data for a larger N. First, the data sets were cleaned by eliminating any participants who did not appear to complete the survey. Students who completed the survey in both the IE and MSE courses were compared using Fisher's Exact Test[177] to the rest of the IE population for removal. These repeat students were eliminated from the IE roster (MSE responses will be used for future participant selection in this project) to have two, independent samples for comparison. Pearson's chi-squared test[177] was used to compare the MSE and remaining IE groups, with no overlapping students. The Bonferroni adjustment[178] was used as the adjustment for running multiple tests at once during all comparisons.

4.3.3 Exploratory Factor Analyses

An EFA to assess the latent correlation structure of the survey items was conducted for validation as new items, C and V, were added to the MAE and a different population was used than in the past. Listwise deletion was used (N=223). A scree plot test[179,180], featuring a plot of the eigenvalues of the correlation matrix, and literature on the theory were used to determine the appropriate number of factors. For the scree plot (Figure 4.2), the "nFactors" package and promax rotation[181] was used in R. Rotation of factors tolerates correlation of variables, provides the simplest solution, and permits items to load into one, and only one, factor[146,182]. The data's skew (absolute value not higher than 2) and kurtosis (value not higher than 7) were evaluated to assure assumptions of multivariate normality were met[183]. Items that had a factor loading below 0.4 during the EFA were removed[184]. In addition to the chi-square (non-significant at $p<0.05$), the root mean square error of approximation (RMSEA) was calculated to test model fit[185]. Cronbach's alpha[186] was used to test the internal reliability of the survey items[187].

4.3.4 Cluster Analyses

A CA of scores of FTP constructs on the MAE survey distributed to second-year engineering students was conducted as this study aims to group homogenous participants into k subgroups, or k clusters[188]. The data for the CA consisted of vectors of composite FTP survey scores (F, PI, FoP) for participants. Two types of CA were compared: Ward's hierarchical and k-means. The most common and generally accepted distance measurement, Euclidean distance[154,189], was used and is standard for Likert-type data.

The Euclidean distance was used for the Ward's CA and the squared Euclidean distance was used for the k-means CA. To run Ward's (and other hierarchical) CA, the "stats" package was utilized with the *hclust* function in R [144]. Plots of the wss and between sum of squares (bss), representing how spread apart the clusters are, were utilized to select k. Similarly, a k-means CA was conducted[142] with the "cluster" package[143] in R[144]. A plot of the wss was used to select the appropriate number of clusters (k), and promax rotation was selected to allow correlation between our survey items during analysis[145,146] as the items were not expected to be unrelated. The *clusplot()*[190] function in R was used to construct figures of each clustering solution and original data. Pairwise t-tests were run to evaluate for significant differences between factor scores for each cluster.

4.4 Results and Discussion

4.4.1 Aggregation of Data Sets

First, the MSE and IE data sets were cleaned by eliminating any participants who did not appear to complete the survey (list-wise deletion). One participant completed the survey twice in the IE course. One of the student's surveys was incomplete and one complete, and the incomplete survey was removed. Some students (N=8) were registered in both the MSE and IE courses. To remove the eight students from the IE sample so the MSE data may be used for future participant selection, the eight students were compared to the rest of the IE group to ensure their removal would not bias the population. This comparison was conducted using the statistical software JMP[191] as it runs all comparisons at once. Because one of the samples was extremely small (IE/MSE common group, N=8), Fisher's exact comparisons was used rather than Pearson's or Likelihood Ratio tests which are unreliable for small sample sizes[177]. Our null hypothesis for each of the 32 tests was that there is no difference between the samples.

The Bonferroni correction[178] was utilized to reduce the familywise error rate (FWER). As simultaneous tests were run, the likelihood of falsely rejecting the null hypothesis increases with each test. The Bonferroni correction, which is considered conservative and simple, uses α/m (where α is the significance level desired for the entire group of tests and m is the number of tests being run overall) as the statistical significance level to test each separate hypothesis. The values for each of the items are shown in Appendix L.

Only one item, C40 ("It's not really important to have future goals for where one wants to be in five or ten years.") was shown to be statistically significantly different for the two groups. This item is negatively worded and given the small N for one of our groups, a response to this question made in error by even a small portion of the group would greatly affect the comparison. As the positively worded version of this item was shown to not be different for the two groups ("It is important to have goals for where one wants to be in five or ten years.") and the other items in the C factor were not found to be statistically significantly different, C40 was deleted for all future analysis. Nine items still remain in the C factor. Since all other items for the survey section did not appear to be different for both groups, the responses from IE course of the students who were enrolled in both the IE and MSE course were deleted. The students' MSE responses were still included in the main data.

To merge the remaining data, the two groups were compared. JMP was utilized to run Pearson's Chi-squared test[177] to test for significant differences between items' scores for both groups. Our null hypothesis for each of the 31 tests was that there is no difference between the samples. When the test was run, 20 items (14-20, 26, 31, 33, 35- 43, and 46) received an error that "20% of cells have expected count less than 5. Chi-Square suspect." When this error occurs, which signifies one of the groups for a particular comparison has a total sum of less than five being considered, often Fisher's exact is used. However, Fisher's is computationally expensive; when the cell count of less than five occurs, Pearson's Chi-squared test is known to be an acceptable approximation to exact Fisher's[177]. Again, the Bonferroni correction[178] was utilized. Appendix M shows the Chi-square value, the p-value, and the Bonferroni adjustment for each test by item. The tests were statistically significant and the null hypothesis was not rejected for any of our comparisons, allowing our data to be aggregated.

4.4.2 Exploratory Factor Analysis

An EFA was conducted on the cleaned responses (N=223) to items in the FTP and E section of the MAE survey because new constructs, C and V, were added to this survey since it was last tested on a similar population (2nd year engineering students) (Kirn, 2014). For this EFA, items using negative language (FoP21, PI26, V30, C36, C39, C40, C41, C43, C46) were reverse scored[192]. A scree plot was created (Figure 4.2) to select the number of factors.

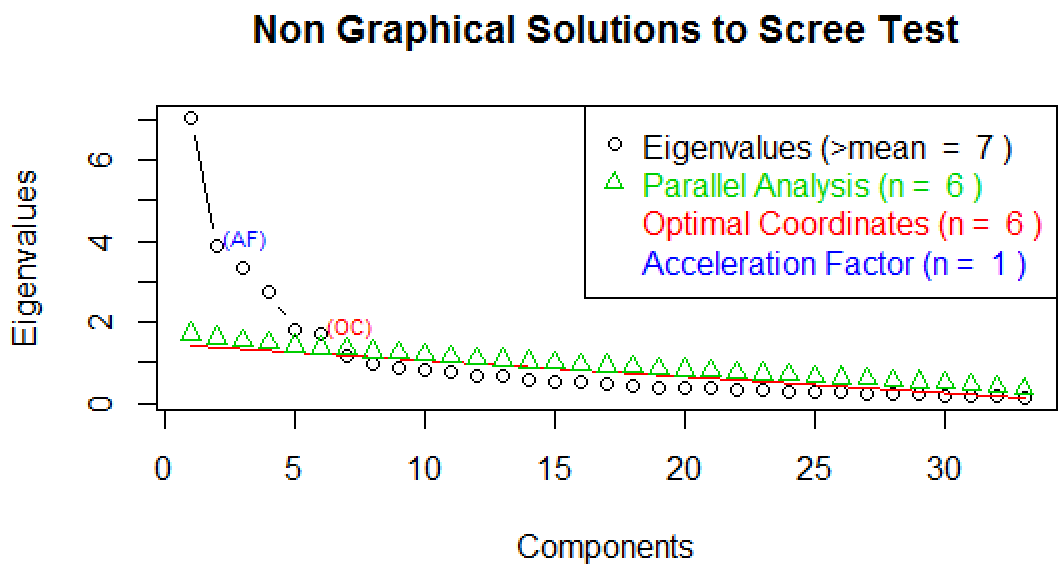


Figure 4.2: Scree plot for entire section of MAE including FTP and E items.

According to the scree plot, six factors is optimal, and six factors was selected due to the founding in literature of the items. Skewness ranged between -1.821 and -.252. The kurtosis ranged from 2.124 and 6.240. Both sets of scores indicated non-normality but were within the level of acceptability for EFA or maximum likelihood factor analysis. Detailed standardized factor loadings for each item may be seen in Table 4.2**.** In the EFA, the chi-square statistic, or difference between the observed and expected covariance matrices, for this section of the survey was 517.33; this was not significant with a p value below 0.05 and 320 degrees of freedom, which means six factors was not an ideal fit.

However, the Root Mean Square Error of Approximation (RMSEA), a goodness of fit measure which ranges from 0 to 1, was also considered as the chi-square statistics may be inflated with large sample sizes and has other known issues[184]. A value of 0.1 or less designates an acceptable model fit; 0.08 or less is considered moderate; a value of 0.05 or less is a good model fit; and below 0.01 is considered excellent[184,185] . The RMSEA was 0.0927 for this model indicating an acceptable fit. Since the RMSEA was acceptable, and theory and prior results support the six factor model, six factors were selected. As the domain- and context-specific constructs (PI, FoP, F) have been shown to be valid for similar populations, the lack of goodness of fit was likely due to the new domain-general factors, which were not utilized in the cluster analyses.

Table 4.2: Exploratory Factor Analysis Results and Cronbach's Alpha for FTP and E Items on the MAE Survey (N=223)

Construct	Item #	Item	Standardized Factor Loadings	Standardized Factor Loadings (without V30)	Uniqueness	Item Reliability (R^2)	Construct Reliability
Connectedness	C36	I don't think much about the future.	0.79	0.79	0.44	0.84	0.86
	C37	I have been thinking a lot about what I am going to do in the future.	0.67	0.67	0.45	0.85	
	C38	What will happen in the future is an important consideration in deciding what action to take now.	0.62	0.63	0.47	0.85	
	C39	I don't like to plan for the future.	0.88	0.88	0.41	0.84	
	C41	One shouldn't think too much about the future.	0.74	0.75	0.46	0.84	
	C42	It is important to have goals for where one wants to be in five or ten years.	0.6	0.61	0.62	0.85	
	C43	Planning for the future is a waste of time.	0.65	0.66	0.52	0.84	
	C45	One should be taking steps today to help realize future goals.	0.47	0.48	0.59	0.85	

	C46	What might happen in the long run should not be a big consideration in making decisions now.	0.44	0.44	0.65	0.87	
	C40	Item removed from analysis due to negative chi-squared test of comparisons	NA	NA			
Expectancy	E24	I expect to do well in this engineering course.	0.78	0.78	0.38	0.84	0.91
	E25	I am certain I can master the skills being taught in this engineering course.	0.75	0.75	0.41	0.82	
	E27	I believe I will receive an excellent grade in this engineering course.	0.91	0.92	0.18	0.91	
	E28	I am confident I can do an excellent job on the assignments in this engineering course.	0.91	0.91	0.19	0.91	
	E29	Considering the difficulty of this engineering course, the teacher, and my skills, I think I will do well in this engineering course.	0.76	0.76	0.39	0.82	
Perceptions of the Future	F15	I am confident about my choice of major.	0.51	0.51	0.65	0.69	0.84
	F16	Engineering is the most rewarding future career I can imagine for myself.	0.86	0.86	0.26	0.88	
	F17	My interest in an engineering major outweighs any disadvantages I can think of.	0.79	0.79	0.30	0.87	
	F18	I want to be an engineer.	0.8	0.8	0.37	0.83	
Future on Present	FoP22	My future career determines what is important in this course.	0.78	0.78	0.41	0.9	0.80
	FoP23	My future career influences what I learn in this course.	0.9	0.89	0.26	0.92	
Perceived Instrumentality	PI14	I will use the information I learn in my engineering course in other classes I will take in the future	0.8	0.81	0.43	0.71	0.82
	PI19	I will use the information I learn in this engineering course in the future.	0.96	0.96	0.18	0.82	
	PI20	What I learn in my engineering course will be important for my future occupational success.	0.8	0.79	0.31	0.78	
	PI21 (FoP21)	I do not connect my future career with what I am learning in this course.	0.45	0.45	0.58	0.78	
	PI26	I will not use what I learn in this engineering course.	0.44	0.45	0.57	0.77	
Value/Valence	V30	Immediate pleasure is more important than	<.4		0.85		

		what might happen in the future.					
	V31	It is better to be considered a success at the end of one's life than to be considered a success today.	0.61	0.61	.6	0.75	0.82
	V32	The most important thing in life is how one feels in the long run.	0.65	0.65	.49	0.79	
	V33	It is more important to save for the future than to buy what one wants today.	0.59	0.59	.62	0.67	
	V34	Long range goals are more important than short range goals.	0.82	0.82	.41	0.79	
	V35	What happens in the long run is more important than how one feels right now.	0.83	0.83	.34	0.84	

The uniqueness, calculated as (1-communality) where communality is the total of the squared item loadings, is reported for each item in Table 4.2**.** In social science literature, acceptable ranges for communalities are between 0.4 and 0.7[182]. The uniqueness value may be thought of as the variance for each item that is not explained by the factors[193], as the communality is the shared variance. Item V30 originally loaded below 0.4 and did not meet the uniqueness requirements and was removed from all future analysis. Items C42, C46, F15, and V33 also fell outside the range of acceptability for uniqueness. Since C and V were new constructs for this population, these items may be poorly written or not fit into this factor. Items C42, C46, and V33 should be altered or deleted in future survey distributions but were considered in the Cronbach's alpha as they loaded above 0.4 in the EFA into the appropriate construct. F15, which also loaded above 0.4, was considered in the Cronbach's alpha testing, which was calculated for each construct. Item reliability and construct reliability are included in Table 4.2. All constructs and remaining items met the acceptable values (Item reliability (R2) ≥ 0.50, Construct Reliability ≥ 0.70, and

Average Variance Extracted ≥ 0.50). In fact, the Cronbach's alpha for each construct was between 0.8 and 0.91, indicating strong internal consistency[194,195].

The item FoP21, originally intended to be included in the FoP construct, loaded into PI. The negative language "I do not connect my future career with what I am learning in this course" lends itself to the PI construct and may have confused students. Due to its significant correlation with the other PI items, the item was moved from FoP to the PI construct for all further analysis. The FoP construct had two correlated items, FoP23 ("My future career influences what I learn in this course.") and FoP 22 ("My future career determines what is important in this course."). These are core components of FoP, but future items may strengthen this construct. Finally, F15 ("I am confident about my choice of major.") was kept for our continued analysis as it meets acceptable levels for the EFA and item reliability but should be checked in future distributions to ensure it is loading acceptably. The final items and factors are included in Table 4.3**.**

Table 4.3: The final MAE survey factors used for analysis

Factor Number	**Factor Name**	**Number of items**	**High Score Definition**	**Factor Items**	**Alpha (α)**
1	Connectedness (C)	7	The person plans and thinks about what they want to do in the future.	C36, C37, C38, C39, C41, C43, C45	0.86
2	Expectancy (E)	5	The person has expectations of success.	E24, E25, E27, E28, E29	0.91
3	Value (V)	5	The person believes that	V31, V32, V33, V34, V35	0.82

			goals attainable in the future are important.		
4	Perceived Instrumentality (PI)	5	The student views what they are doing in the present as useful.	PI14, PI19, PI20, PI26, FoP21	0.82
5	Perceptions of the future (F)	4	The student has a positive and clear outlook about the future.	F15, F16, F17, F18	0.84
6	Effect of future on present (FoP)	2	The student believes the future has a high impact on what the student does in the present.	FoP22, FoP23	0.80

4.4.3 Cluster Analysis

Hierarchical Cluster Analysis

First, a data matrix was created with course, ID, and FTP item responses. Participants were removed (four in total) who had missing responses in the domain-specific FTP factors (PI, FoP, F). Composite scores of the factors were created so that each participant had a single score for each factor. Euclidean distance was selected as the standard measurement between two vectors in the dist algorithm in R. The *h.clust* function was utilized to select the hierarchical method. In this method, missing values are omitted by the algorithm automatically. Multiple hierarchical clustering algorithms were run and dendrograms created. Figure 4.3 shows a cluster dendrogram for a single link clustering algorithm using the *hclust* function in R. Single link was not a suitable fit for the data as it caused chaining, visualized a several single data point clusters on the left of Figure 4.3, which this algorithm is prone to do. Other issues occurred with hierarchical algorithms, but Ward appeared to be a strong candidate. The Ward clustering algorithm results are later discussed.

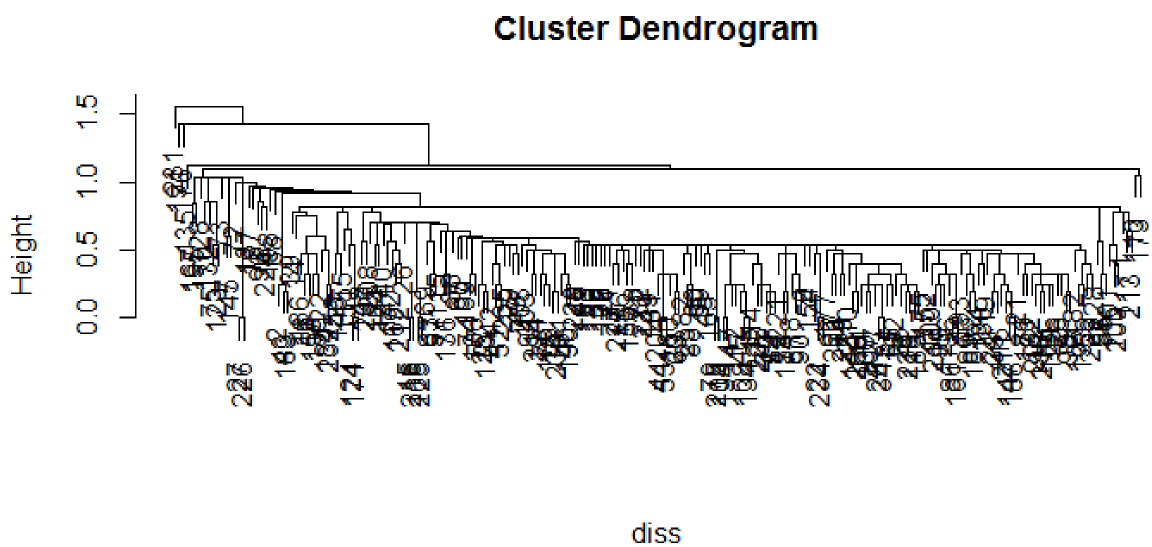


Figure 4.3: A Cluster Dendrogram created through hclust for the single link clustering algorithm using the domain- and context-specific FTP items of the MAE survey for the IE and MSE responses

<u>Ward Clustering Algorithm</u>

To run Ward's, the *ward.D2()* function was used[157,196], which uses Ward's clustering algorithm and squares dissimilarities before updating clusters. A clustering dendrogram for *ward.D2* (see Figure 4.4) along with two additional plots, graphs plotting the bss and the wss (see Figure 4.5**)**, were created to determine the appropriate number of clusters.

The significant height difference between the "trees" in the clustering dendrogram (illustrated by the dashed line) in Figure 4.4 supports k=3. The two "elbows" of the bss and wss in Figure 4.5 (illustrated by the circles) show k=3 as an ideal clustering solution. Agreement between the dendrogram, the wss plot, the bss plot, and previous literature[36,39,40] show that a three cluster solution is likely. When selecting k=3, the total sum of squares is 991.00; total within sum of squares is 527.11; and between sum of squares is 463.89. The average scores for each factor (F, PI, and FoP) are detailed in Table 4.4, as well as the size of each cluster and the standard deviations. The visual representation of the Ward's cluster analysis for k=3 can be seen in Figure 4.6.

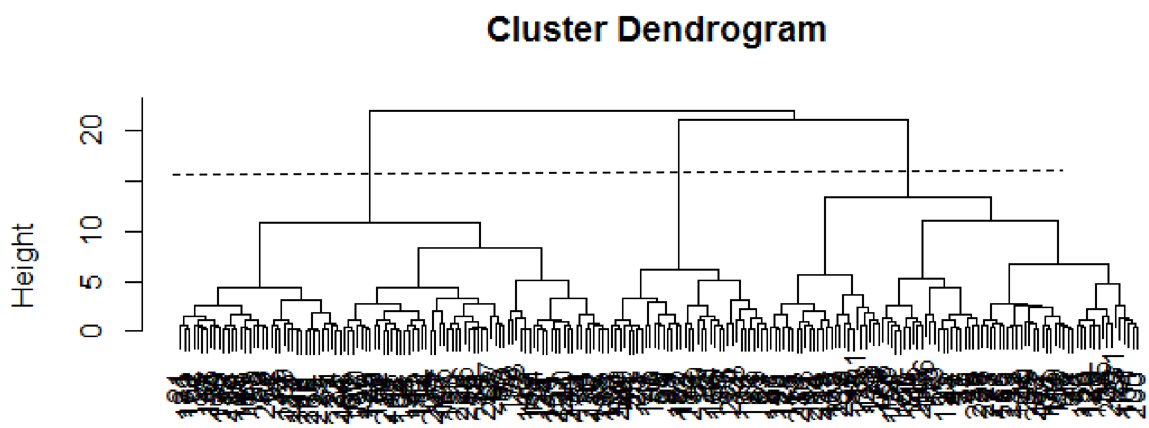


Figure 4.4: Ward's CA (ward.D2 in R) Dendrogram depicting three distinct clusters for the domain- and context-specific FTP items of the MAE survey for the IE and MSE responses

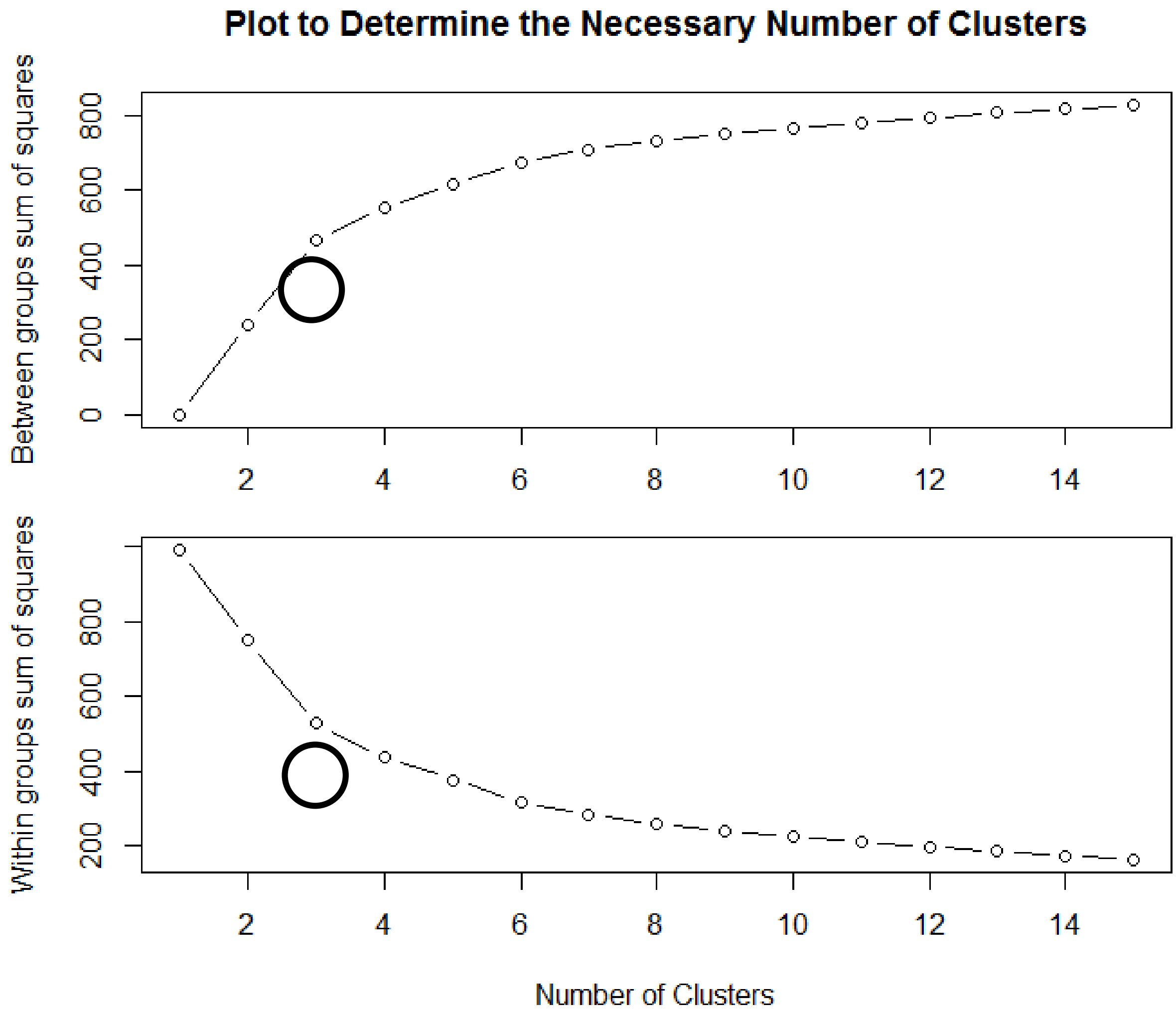


Figure 4.5: Ward's CA (ward.D2 in R) plots of "Between group sum of squares", and "Within group sum of squares", both depicting a three cluster solution for the domain- and context-specific FTP items of the MAE survey for the IE and MSE responses

Table 4.4: Clusters and average cluster variable scores for three variable Ward's CA in R with k=3

Cluster	N	Perceptions of the Future	Perceived Instrumentality	Future on Present	Cone Type
1	86	5.01 ± 1.10	4.56 ± 0.82	4.08 ± 1.21	Waffle
2	100	6.12 ± 0.76	6.18 ± 0.62	5.07 ± 0.93	Sugar
3	37	6.14 ± 0.82	6.32 ± 0.63	2.03 ± 0.79	Cake

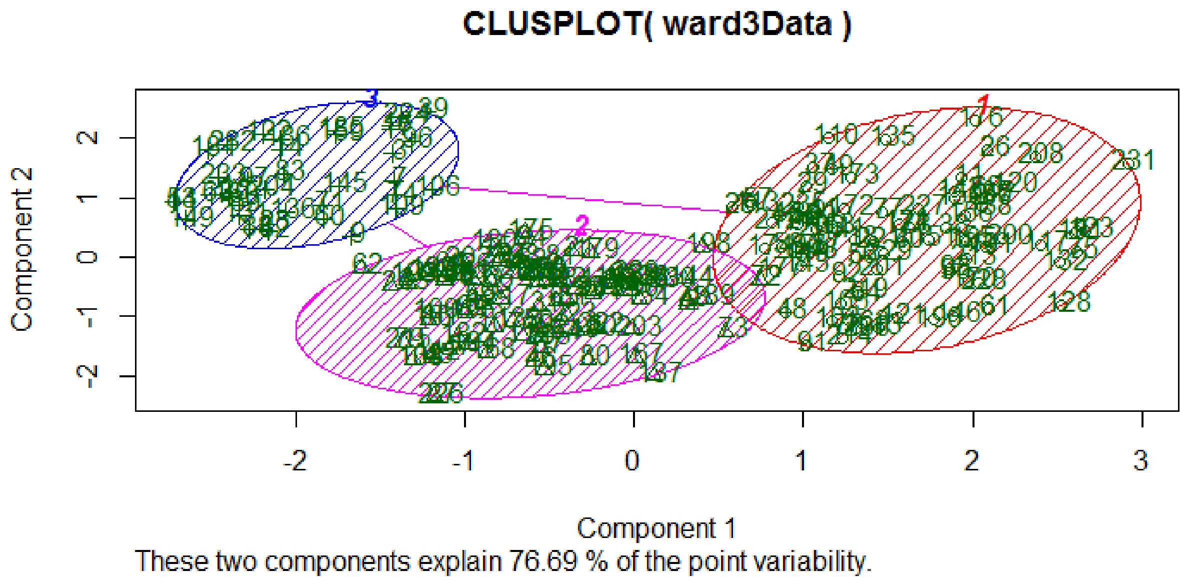


Figure 4.6: A Ward's three cluster solution two-dimensional visual representation using CLUSPLOT in R explaining 76.69% of the point variability

Pairwise t-tests were run to look for significant differences between factor scores for each cluster. Clusters 1 and 2 differ significantly in terms of F. Additionally, Clusters 1 and 3 differ in the F construct. However, Clusters 2 and 3 have relatively high values for this construct and do not differ. For PI, Clusters 1 and 2 differ as do Clusters 1 and 3. The PI is not significantly different between Clusters 2 and 3 (sugar and cake). Finally, for the FoP construct, all factors across cluster pairs differ significantly. From this analysis, the only significant difference shown between Clusters 2 and 3 is FoP.

K-means Clustering Algorithm

A scree plot was created and the elbow (k=3) used to select the number of clusters (see Figure 4.7). The tss, wss, and bss are 991.00, 482.81, and 508.19, chronologically. The k=2, 3, and 4 clustering solutions were run for testing purposes and k=3 appeared to be the best fit, with the least overlap in clusters and tightest cluster solution. Table 4.5 shows the k-means three cluster solution, and Figure 4.8 displays the two-dimensional visual representation explaining 76.4% of the point variability. Three dense clusters, with few outliers and little to no overlap are shown. Pairwise t-tests showed significant differences between all three FTP factors, F, FoP, and PI, for clusters 1 and 2 and between clusters 1 and 3. However, clusters 2 and 3 only differed significantly in student views of the impact of the future on the present (FoP).

Figure 4.7: K-means CA wss plot, depicting a three cluster solution for the domain- and context-specific FTP items of the MAE survey for the IE and MSE responses

Table 4.5: Clusters and average cluster variable scores for three variable k-means CA in R with k=3

Cluster	N	Perceptions of the Future	Perceived Instrumentality	Future on Present	Cone
1	56	4.48 ± 0.98	4.60 ± 0.96	4.26 ± 0.83	Waffle
2	58	5.99 ± 0.83	5.83 ± 1.03	2.25 ± 0.83	Cake
3	109	6.17 ± 0.66	5.95 ± 0.82	5.17 ± 0.88	Sugar

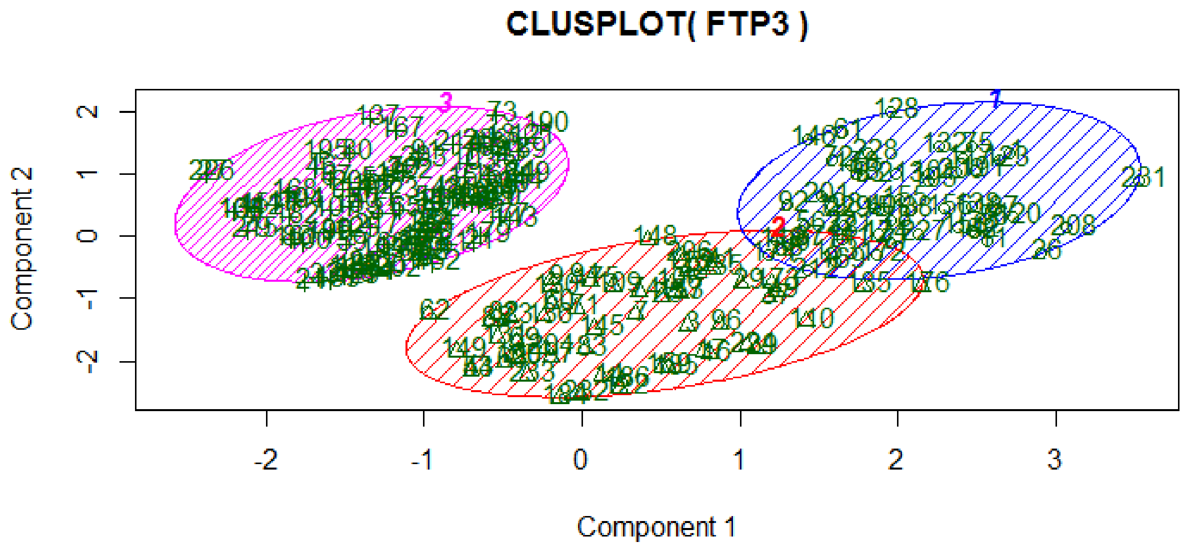


Figure 4.8: A k-means three cluster solution two-dimensional visual representation using CLUSPLOT in R explaining 76.4% of the point variability

4.4.4 Selection of Clustering Algorithm

The k-means solution appears extremely similar to the Ward's clustering solution in mean scores. Ward's cluster 1 and k-means cluster 1 have medium scores; Ward's cluster 2 and k-means cluster 3 have high average scores; and Ward's cluster 2 and k-means cluster 3 have high perceptions of the future and PI scores but low FoP scores. Additionally, the t-tests showed the same dissimilarities between the clustering solutions in regards to average scores across clusters. However, the size (number of participants) of these "matching" clusters appear different for the two methods. The difference in the number of participants in each cluster is likely due to the fact that the k-means algorithm will reconsider participants during the iterations, while Ward's CA algorithm does not allow for a change in cluster once a data point has been placed into a cluster.

The goodness of fit scores showed that k-means was the best fit for this set of data as the wss was smaller, showing more compact clusters, and the bss was larger, showing more distinct clustering solution. Additionally, prior results and theory showed that a three cluster solution is appropriate for MAE survey data. Due to the lower wss and higher bss value, the match between results and theory, the fitting visual representation, and the robustness of the method, the k-means clustering solution was selected.

4.5 Conclusions, Future Work, and Limitations

It is important to note that the best method is heavily dependent on the data set. For example, though single linkage was not successful for this data, this method would be useful to find long chains of data that are related. While Ward's and k-means provided similar solutions with strong results, k-means provided a more robust measure, possibly because it allowed for movement of data between iterations. The goodness of fit scores showed that k-means was the best fit for this set of data. Visually, both methods appeared to have achieved distinct clusters with strong clustering solutions. While the results from each CA were not identical, similar solutions did occur with enough evidence to select three clusters and to group similar students together. Similar average scores for each cluster were achieved.

The theory of three FTPs (domain- and context-specific) of undergraduate engineers appears to fit this population. The clustering solution from this work will be utilized as a piece of participant selection in Chapters 6 and 7. The MAE survey currently considers endogenous, and not exogenous, PI, but waffle cones appear to have a high exogenous PI.

For this survey, waffle cones have all medium scores, all high for sugar, and high for F & PI but low FoP for cake. However, a future version of the MAE should include exogenous PI items to provide a better measure of the PI of engineering students. Moreover, PI is a domain-specific way to look at connectedness; the MAE survey would provide a stronger look at domain-specific FTP by including domain-specific value/valence items to complete this picture. Furthermore, while this work analyzed three domain- and context-specific FTP constructs (F, FoP, and PI), future work should look at a more domain-general approach to FTP and the distinctions between undergraduate engineers. Additional work could include looking at different majors, transfer versus non-transfer students, genders, and other classifications.

In future work, the MAE survey should be further studied for this population. The C and V constructs should be evaluated and refined utilizing student focus groups and other means. Additionally, item FoP21, originally intended to be included in the FoP construct, loaded into PI in this analysis. The negative language “I do not connect my future career with what I am learning in this course” lends itself to the PI construct and may have confused students. The item should be altered or reconsidered for future analysis.

CHAPTER FIVE

5. Future Time Perspective and Self-Regulated Learning: A Mixed Methods Participant Selection of Case Studies in a Major-Required Course

5.1 Introduction

This chapter explains the selection of case study participants as the first phase of a mixed methods sequential explanatory study of connections between the motivations of second-year engineering students, in particular their views of the future, and their self-regulation of their learning in the present. At this point in the study, students had completed a survey during class about their motivations (in the fall semester), three journal reflections about their study habits (in the fall semester), a second round of the survey (in the following spring semester), and an interview about their motivation (views of the future) and study habits. For the purpose of selection of the case study participants for the larger study, the analysis of the two surveys and the portion of the interview related to the students' future views will be discussed in this chapter.

5.2 Background

5.2.1 Future Time Perspective and Self-Regulated Learning

A pilot study was conducted that examined the extent to which a quantitative motivation survey matched qualitative interview data focused on students' Future Time Perspectives (FTPs) matched in terms of FTP characteristics. The same study explored connections between FTP and students' Self-Regulated Learning (SRL) strategy use. This pilot is described in Chapter 3.

5.2.2 Selecting Case Study Participants

A multiple case study design was utilized in this phase of the study to discover how the FTP of second-year engineering students is connected to their SRL strategy use. The cases should be selected to vary by FTP characteristics, and multiple cases will support the validity of a model created by this work[197], providing more robust, compelling, and thorough results than single case studies. Even if the cases differ, if common conclusions are reached for such varied cases then the conclusions are much more generalizable. Cases should be selected with similar attributes for replication and produce either "similar" or "contrasting" results[197] (p. 53). Using theory for sampling meets the criteria of appropriateness, which relates to fitting research question(s) and theoretical framework(s) at hand[198]. Following the method of "criterion" or "theoretical"[199] (p. 182-183) case selection based on *a priori* theory, participants will be selected from each of the characteristic FTP clusters (see Chapters 1 and 4), which according to hypothesis will have contrasting use of SRL strategies due to their FTP type. For example, the FTP cone model and prior research shows that FTP characteristics, such as a high Perceived Instrumentality (PI), will stimulate use of SRL strategies[13,40,60]. This research hopes to further examine which SRL strategies second-year engineering students use, and how, when, and why they use them.

An example two case multiple case study, described by Yin[197], contrasted two approaches to educational accountability with a higher-cost, more-complex and a lower-cost, less-complex version for implementing the accountability. In that example, educational accountability varied in two contrasting ways, which served to detail and compare the distinct cases. Often, multiple case studies are utilized to replicate findings to build a stronger, more generalizable theoretical model. Additionally, cases can be selected if they are rich in information, often termed an "intensity case"[199] (p. 182). To ensure that the selection of the cases is adequate, which refers to how many cases is appropriate or enough, selection criteria can remain flexible[198]. The selection of cases should be purposeful to investigate new theories or interpretations, and thus an information-rich sample is preferred over a generalizable population.

5.3 Research Questions

Based on FTP theory and prior results with engineering students (see Chapters 1, 3, and 4), there are three characteristic types of FTP. The goal of this phase of the larger research project is to select three cases with different FTP types to provide evidence of the SRL strategy use and connections between SRL and FTP for each characteristic FTP type. Based on quantitative results from the pilot study (Chapter 3), this chapter describes seven participants' FTPs and connections between their FTP and perceptions of present tasks, specifically SRL strategy use. The results of the analysis of the surveys and interview data for the seven participants are included, addressing the primary research questions for this chapter:

> RQ1: Based on quantitative and qualitative analysis, what are the different motivational (FTP) profiles of undergraduate engineering students within the context of a major-required course?

RQ2: In what ways do students' motivational (FTP) attributes relate to their present SRL strategy use?

5.4 Methods

5.4.1 Participants

Students (N=97) enrolled in a materials science and engineering (MSE) course during a fall semester were invited to participate in this study in a single academic year. This course is completed typically by second-year students in biomedical engineering (BME), mechanical engineering (ME), industrial engineering (IE), and MSE but a small portion of students elect or end up taking it in a later year due to scheduling or registration issues. This course was selected because it provides access to students in multiple engineering majors at a similar point in their curriculum. The setting of this project around a course allowed us to take into account the academic environment, which is a component of strategic learning[15] and to focus on context-specific and task-specific aspects of FTP.

5.4.2 Data Collection

During fall semester, the students completed the Motivation and Attitudes in Engineering (MAE) survey (N=97) (see Appendix N), attended the SRL "Study Cycle" intervention (see Chapter 2), and then journaled about the study skills they used during each two-week period preceding their exams in the course (N=96, 73, 76, respectively). They received course credit for their journal entries. In the following spring semester, the same group of students was invited to complete the MAE survey and participate in a one-hour interview (see Appendix E for interview protocol) discussing the student's FTP, SRL, and the connections between them. Of the 97 invited MSE students, nine participants completed the survey, and seven of these nine attended the interview.

The MAE survey consists of five sections, and the one section included in this analysis focuses on Expectancy and five factors of FTP: Perceived Instrumentality (PI), Perceptions of the Future (F), Effects of Future on the Present (FoP), Value (V), and Connectedness (C). Items about Expectancy for this population generally rank relatively high on a Likert scale as they all have high expectations of success in their engineering courses during their second-year of study. Three of the factors, PI, F, FoP, are domain- and task-specific, as they refer to engineering (domain) or ask the student to reflect on activities within an engineering course (task). The V and C factors are domain-general, as they refer to FTP characteristics that have evolved since childhood, are typically stable, and are measurable outside of a domain or context[30].

The questions posed to students for each journal reflection were:

> Write a minimum of 250 words addressing all of the following prompts:
>
> 1) What study strategies did you utilize to study for the first exam?
>
> 2) Did you set goals when studying for your exam? If yes, discuss how setting these goals affected your study strategies. If no, discuss how not setting goals affected your study strategies.

Students in the first-year engineering program at Clemson University often attend study skill workshops, and they may have seen some of these SRL strategies previously. In the fall, 28.7% of all undergraduate engineering students at Clemson attended at least one workshop provided by the Academic Success Center (ASC). (For details on engineering versus non-engineering workshop attendees, see Appendix O and P.) These workshops provide a range of topics such as learning strategies, study groups, and campus resources. While the SRL strategies may have been familiar to some of the participants, the Study Cycle intervention established a shared common knowledge of the strategies (allowing greater fluency in their journaling and more even representation of the strategies) and to build rapport with the researcher.

5.4.3 Mixed Methods Sequential Explanatory Research Study

A mixed methods approach, specifically a multi-phase sequential explanatory design, was used to analyze the relationship between student FTP and SRL strategy use through exploration of sub-goaling (described in Chapter 1). In the first phase, the students in the MSE course completed the MAE survey and three sets of journals in the fall semester. Students were recruited from this same population to complete the MAE survey again and be interviewed about their SRL strategy use and FTP. This interview protocol was piloted to test for quality and the richness of data collected[40] (Chapter 3) and is shown in Appendix E. The MAE survey and FTP interview data for recruited students was analyzed for purposive sampling for participant selection. The cluster analysis assisted with participant selection; the cluster in which each student was placed was confirmed by comparing the cluster analysis of the fall data, the updated MAE survey FTP item scores from the following spring, and the FTP data from Interview 1 in that spring. All of the FTP data elicited from the surveys and interview were considered for selection: MAE Survey fall semester, MAE Survey spring semester, and Interview 1.

A cluster analysis was run on the MSE MAE survey data from the fall semester. Before the CA was run, the data sets were cleaned, and the MSE data was combined with data from students in an IE course, after successful comparisons of the two data sets, to increase the sample size. After validity and reliability testing[186,200], a k-means cluster analysis[143] was used to place students into homogeneous subgroups[188]. The interviews for each participant were analyzed using directed content analysis[147] with the SRLIS framework (see Chapter 2)[63] for the SRL portion and the FTP cone-type model and characteristics[36,50,52] for the FTP portions. Directed content analysis utilizes *a priori* theory but allows for additional themes to emerge from the data.

Engineering students have been shown to place into three categories, which was verified for this population in Chapter 4. The FTP of the seven participants will be determined by comparing multiple pieces of data from multiple time points: the MAE survey in the fall semester, the MAE survey in the following spring semester, and transcript data from the first interview. FTP is a time-and context- sensitive construct[25,30]. Students may have consistent FTP types at multiple points of data collection; however, due to the nature of FTP, student FTP types may have shifted over time and within context. One ideal group of cases will have maintained a consistent FTP type during all time points, as this consistency will make analysis and comparison easier. However, while consistent FTP is preferred, rich and comparable cases, specifically “intensity” (data-rich) and “theoretical” (using theory or a framework), will be selected which will most support theory development. For example, considering students of one cone type will allow for a comparison within the context of a single FTP type (“theoretical” selection). A contrast of the use of SRL strategies will allow for development of theory of the connections between SRL and FTP. The participants must have a rich FTP and SRL description to be selected and must have completed all three journals in the MSE course ("intensity" selection). While this chapter begins to build on the theory of the connections between FTP and SRL, it primarily allows for a selection of suitable participants for further data collection and analysis to describe this phenomenon. Thus, participants who are similar in most aspects but different in one significant aspect may be considered. Overall, case study participants will be based on different FTP types.

5.5 Results and Discussion: Participant selection

5.5.1 Cluster Analysis

The seven voluntary participants, students in the Fall MSE course in the Fall, who completed the MAE Survey in the fall semester, completed the survey again in the following spring semester, and attended an interview about FTP and SRL were considered for analysis. Table 5.1 shows the composite scores for the MAE Survey domain- and context-specific FTP constructs (Perceptions of the Future (F), Perceived Instrumentality (PI), Effects of Future on the Present (FoP)). The MAE survey PI items focus on endogenous PI, which limits the measurement of this construct. For example, Waffle Cones appear to have a high exogenous PI, which should be measured in future surveys. During the next spring, the students were asked to reflect on a course in which they were currently enrolled in the current semester, while the fall survey asked for reflection on the MSE course. The course each participant chose to reflect on during their completion of the spring survey and the participants' majors are included in

Table 5.2. Majors include BME, ME, IE, and MSE.

Table 5.1: Clusters and average cluster variable scores for three variable k-means CA in R with k=3 from Chapter 4.

Cluster	N	Perceptions of the Future	Perceived Instrumentality	Future on Present	Cone
1	56	4.48 ± 0.98	4.60 ± 0.96	4.26 ± 0.83	Waffle
2	58	5.99 ± 0.83	5.83 ± 1.03	2.25 ± 0.83	Cake
3	109	6.17 ± 0.66	5.95 ± 0.82	5.17 ± 0.88	Sugar

Table 5.2: Composite domain- and context-specific FTP scores, and cluster for seven interviewed students based on MAE survey and interview data analysis.

Student Information		**Fall**				**Spring**				
Name	**Major**	**F**	**PI**	**FoP**	**Cone Type**	**Course**	**F**	**PI**	**FoP**	**Cone Type**
Anna	BME	3.5	6	2	Cake	Mid-year MSE course	3.25	4.8	3	Waffle
Barb	BME	4.5	6	3.5	Waffle	Mid-year BME course	3.75	4	3	Waffle
Cody	ME	3.75	7	1.5	Cake	Mid-year ME course	6	5.8	1	Cake
Dana	IE	6	7	2	Cake	Mid-year IE course	4.25	5.6	6.5	Sugar
Erin	BME	5	6.33	3	Cake	Mid-year BME course	3.75	5	3.5	Waffle
Faye	IE	4.5	3.67	5	Waffle	Mid-year IE course	4.25	5.6	4	Waffle
Greg	MSE	5.75	7	4.5	Sugar	Mid-year CE course	6.25	5.6	2.5	Cake

5.5.2 Qualitative Results for Cases

5.5.2.1 Anna

Future Time Perspective: Anna is a white, female BME major in her second-year at the university. She said she is "wishy washy" in terms of choosing a career path and is pursuing engineering because of it: "…most people will hire someone with an engineering degree." She considers engineering "…anything that will make you more efficient at the problems." In an ideal world, Anna would be a calculus professor;

however, she said she has ruled out being a calculus professor due to the low income and stringent standards. Finances are a main driver for Anna's decisions as she also believes that money may again alter her career path as "grad school is expensive." Currently, Anna is pursuing a position as a pediatric oncologist, her distal future career goal (DFCG), with a proximal sub-goal of conducting research between college graduation and medical school. Anna's well-defined path of "realistic" goals which lead up to her DFCG are included in a timeline in Figure 5.1, and she described her conflicting ideal and realistic futures, "Right now I'm thinking about med school, that's the main one. I'm thinking of pediatric oncology but I'm not really sure. I kind of go back and forth between that and getting a master's in teaching, which is kind of different."

Anna has a strong sense of endogenous PI for her coursework and many skills she is learning ("Communication skills and then compassion. Being able to think through problems.), because she feels all of it is relevant to any of her potential career paths: engineering, medical school, and mathematics teaching. While Anna only plans to use engineering for her one to two years of research after graduation, she thinks calculus will be important in this position. She does not consider medicine or math teaching engineering-related, but she does see how her biology and anatomy classes may be relevant for medical school. Anna views communication and compassion as instrumental for a mathematics teaching position; she believes thinking quickly and being calm as important as a doctor. She said, "Mainly being able to think quickly and react in a calm manner [is important for being a doctor.]…You could even go that way for calc professor." Though Anna realizes she realistically will not be a math professor, she is currently substituting at an elementary school, working as a calculus tutor, and has accepted a position at a math learning center for the next summer; all of these positions are relevant to this “ideal” future. Anna has conflicting views of her future and fits quantitatively (spring survey) and qualitatively into a Waffle Cone. This is a quantitative shift from her Cake Cone MAE survey cluster in early fall; this shift may have occurred over the fall semester after her decision to pursue medical school and will be considered if Anna is selected as a participant.

Self-Regulated Learning: Anna utilizes *organizing and transforming* (makes and utilizes lists, outlines steps of problem, labels the types of problems) and also *rehearsing and memorizing* (review or rewrite the list for memorization, flashcards) strategies. For general use of these strategies, she specifically said,

> Generally, after class I'll outline, especially since most of my classes are math, so I'll outline the steps to solve each problem, and then write out what kind of problem it is on the side. Those are the main things. I make lists of stuff you have to straight up memorize, but there's not as much of that in classes I'm in.

She gives a specific example of a course she is taking and said, “For MSE it's mainly looking at old homework problems, outlining them, defining what type of problem they are, and then looking at the derivations.” She also uses k*eeping records and monitoring* (lists to know she has gone over everything/ knows all topics on each test and then has them compiled for the final). Anna *structures her study environment* by practicing with timed exams without any other materials (no notes, computer, or phone). Finally, she uses *seeking social assistance* and *self-evaluating* by studying with her peers, as described when she said, “Most of my friends are in the same classes, because we're all in the same major. Sometimes we'll recite stuff to each other, recite how to do problems, and if you can't do that then you know you've tricked yourself.”

Connections: Anna is conflicted about importance of material in her courses and is self-regulating at a high level in her engineering-, mathematics-, and medical-related courses due to her divergent future goals. She regulates due to proximal sub-goals related to these potential career paths: “Since I have to take the MCAT and then the FE also, you kind of have to actually know the material. The study skills kind of help you actually learn it instead of memorize it.” Anna uses her future goals to help prioritize the importance and study time for each of her courses, and she said “I guess it determines what importance I put on what classes, especially if I have more than two or three exams in a week, rank them, prioritize them based on what I think will be most useful.” Because of how she views her courses and the characteristics she finds important for her conflicting futures, Anna studies to know material for exams, to do well in classes, and to know information for the future. For example, Anna keeps notes for her important classes as she knows she may use them later when studying for professional exams and in future positions: "I keep really good notes. It's not necessarily remembering, but I can reference back pretty easily. Like I said, generally the stuff that you really need to know you just remember because it's drilled in." While Anna’s timelines in Figure 2 shows a path of proximal sub-goals that lead Anna to a DFCG working in pediatric oncology, Anna self-regulates in courses related to medical school due to this goal, in engineering courses due to her goal of conducting research for 1-2 years, and in her mathematics courses due to her “ideal” future of becoming a math professor.

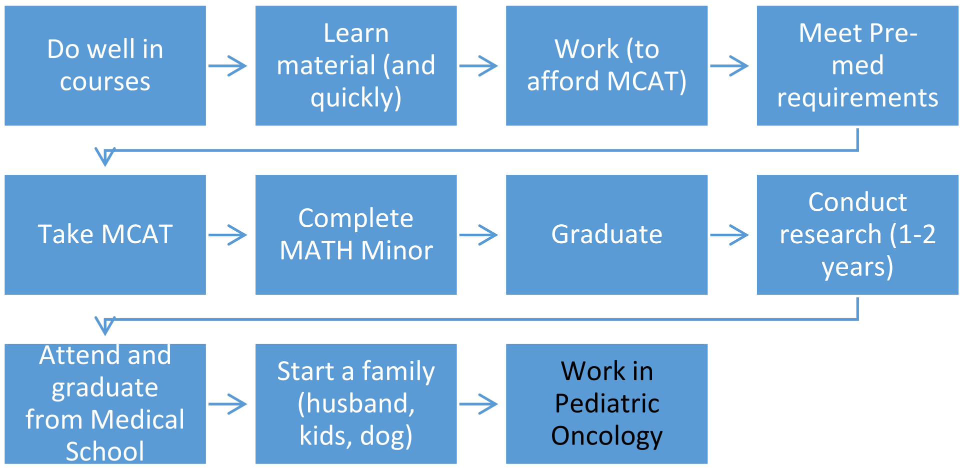


Figure 5.1: Anna’s timeline of proximal sub-goals and distal future goal relating her FTP and SRL. Her well-defined set of goals relating to her DFCG support her proximal sub-goals and thus her self-regulation.

5.5.2.2 Barb

Future Time Perspective: Barb is a female, Asian second-year student who is majoring in BME who does not intend to use engineering and wants to become a pharmacist after graduation. She is interested in earning a doctorate to feel self-accomplished and to please her family. Barb decided against medical school due to a negative experience at a summer internship; her previous goal was to become an anesthesiologist after graduation. Barb decided on a new DFCG, a dual practicing and teaching pharmacist position, after a shadowing opportunity. However, Barb believes she has a lot of options open for what she "can be" in the future, and she uses her and other’s experiences to help guide her decision-making. For example, while Barb does not plan on being in an engineering-related profession after graduation, she feels her plans could change if she finds she does not like pharmacy. Barb's beliefs about her future and her DFCG motivated her to pursue related things in the present: a design project in BME, a summer research internship for the government related to drug abuse, and a summer international experience in BME related to drug delivery. Barb believes these experiences and her coursework "…definitely provides a foundation for me to then use those skills to build on it and use them, but then also gain new ones."

Barb plans to use BME as a backup career in case she does not end up pursuing pharmacy. She is avoiding careers such as art. Barb believes some of her current coursework and experiences are relevant to her future: anatomy, leadership, work ethic ("amount of work"), organizational skills, working well with others, and communication skills. Overall, while her DFCG is her position as a pharmacist, her primary goal is to have a career in the medical field. Based on her interview, Barb has a typical Sugar Cone FTP, with a well-defined set of future goals, a DFCG which motivates adoption of proximal sub-goals, high PI for career- and course-related activities, a strong sense of connection between the future and the present, and adoption of activities in the present to support her future goals. Barb classified in a Waffle Cone in fall, which is supported by Barb's explanation of her confusion of career choices after her summer internship. Barb's spring survey scores are also quantitatively Waffle Cone, which does not match her interview results. A cone-type shift may have occurred or the MAE survey may not have quantitatively measured Barb's true qualitative FTP. Likely, this mismatch is due to the context of the MAE survey, as Barb reflected on an MSE course in the fall and a BME course in the spring. Barb’s Perceptions of the Future score is medium, likely due to the fact that she plans to pursue medicine and not engineering. Also, these conflicting scores highlight the importance of context for FTP, in particular the importance of utilizing a singular context when comparing a group of students.

Self-Regulated Learning: Barb claims to use the same study skills for her engineering and non-engineering classes but can articulate specific SRL strategies used for differing material/classes. She utilizes *seeking social assistance* and *self-evaluating* most heavily and for all of her coursework. Barb believes that the definition of studying is "to be able to comprehend all of the material and be able to explain it to another person." She reiterates later she knows she has learned something “definitely when I can teach it to other people. Like say in a group or something". This type of learning is considered s*elf-evaluating* and *seeking social assistance*, as Barb uses the group to confirms she knows the information but also completes work and learns using other students. Barb is also inclined to use study groups when learning, but she *self-evaluates* and *changes the environment* by leaving if the group is being unproductive. Barb is more likely to *seek social assistance* from a professor if s/he is teaching her major course. Barb utilizes *rehearsing and memorizing* in the form of notecards (for biology) and *seeking information* (Khan Academy and other online resources). Barb listens primarily in lecture and does not take notes (*changing study environment, self-evaluating*) due to efficiency: "I feel like for me it is more efficient, just because if I try and note take while listening, I normally will only get half of each, and that doesn't help anyone. It just seems to be a better method for me." She knows this from past experience: "I know that when I was younger, say like my parents were telling me something and I was writing it down, I would normally ... If it was one sentence I would have to have them repeat it like three times for me to get it all down. I guess just realizing that when I'm notetaking I only get part of it."

Connections: While Barb verbalizes that she does see a connection between her future career and how she studies, she is very grade driven: “[Grades are important because], just personally, knowing that I can do the best that I can basically do. Also, obviously they are important to other people as in pharmacy schools.” Barb self-regulates and studies in her courses to do well, and her DFCG motivates her proximal sub-goals, such as attending pharmacy school, which in turn motivate her to self-regulate in her courses and during relevant external experiences, such as internships and research (endogenous PI). However, Barb’s goal to attend pharmacy school drives her to earn good grades to increase her chance of acceptance (exogenous PI). Barb’s timeline including her DFCG and proximal sub-goals which motivated her self-regulation may be seen in Figure 5.2. Overall, Barb uses engineering study skills, even though it is her backup career, to learn how to do new things and be able to apply what she has learned later for new hobbies and new ideas. She believes self-regulation is important in learning as "there's always work that's going to have to be done, and so the more efficient it can be, the better you'll be at your job” and she uses SRL for “whatever goal I’m working at at the moment.”

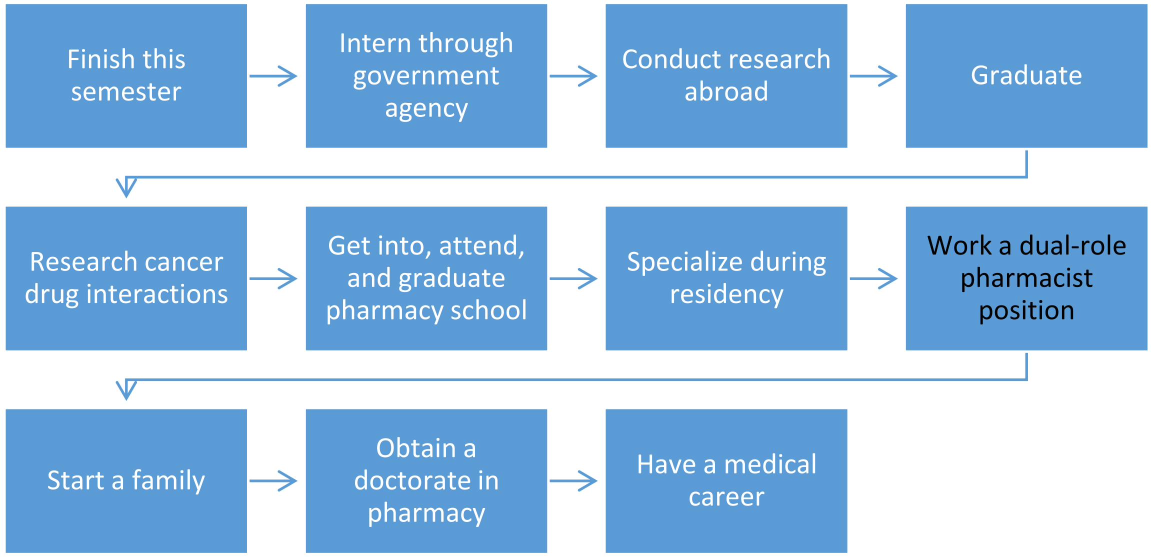


Figure 5.2: Barb's timeline of proximal sub-goals and distal future goal relating her FTP and SRL. Her well-defined set of goals relating to her DFCG (Become a pharmacist) support her proximal sub-goals and thus her self-regulation.

5.5.2.3 Cody

Cody is a white, Caucasian, male ME major with a long list of clear goals supporting his future DFCG: hold a creative board position. Cody defines engineering as "…anything where you do have to break down those projects, or you have to break things down into parts and then assign a task or create a model for it." He sees renewable energy and aerospace as two paths to obtain his DFCG and is currently pursuing energy, with aerospace as his backup. In the renewable energy field, he believes he is interested in consulting in a humanitarian project, being a researcher in nuclear fusion or "alternative research," or starting a company of his own. Cody sets himself up with future-relevant projects and experiences; for example, Cody is actively striving toward research at the moment, as he sees that as potential in his career working in renewable energy. Cody does not want a 9-to-5 engineering job and has ruled out things through past experiences (e.g. park tourism due to inability to support a family on the salary). Cody sees many possible desired future paths (listed as goals in the path in Figure 5.3) and is open to change, particularly if he feels what he is doing is “not fun.” Cody realizes his goals may change if he realizes that is not what he ends up wanting to do. Cody can see himself in ten years with a career, married (or “super single”), and working toward his goals. He is currently pursuing the humanitarian side of engineering and has joined a research experience at the university.

Cody’s short-term goals are clearly defined and have a timestamp for achievement. When Cody discusses internships, he is unclear which will work out best but allows his experiences to motivate his career path (options appear as working in an energy company, having a government energy position, and working in an aerospace company). A research project with a national AE organization motivated these goals. Cody sees an impact of his future on his present; he believes his ME degree will help him impact the environment "indirectly" as employers will hire for engineering-related skills and he plans to have a position which will work towards sustainability and renewable energy using these skills. Also, Cody sees a connection between what he does in the present and its effect on the future; for example, Cody sees thinking as an engineer, which he learned in thermodynamics, as relevant to his future. Finally, Cody believes his engineering coursework, such as statics, dynamics, and physics, are relevant to the positions he will hold later. Cody wants a position where he can do research, create change, think critically, and come home feeling like he did "real work.” He believes people skills, confidence, making connections, a strong GPA, globalization, data analysis, multi-discipline skills, and entrepreneurship are important characteristics to his ideal self.

Cody clusters as a Cake Cone based on his survey scores in the fall and spring, but based on his interview, he appears to be a Sugar Cone. While his MAE FoP score is low, Cody is clear about how his future and present relate and makes strong connections. Cody has likely shifted from a Cake to a Sugar Cone student and his choice of class for reflection and the small number of FoP items may have affected the mismatch. If selected, additional interview questions related to FTP will help form a stronger picture of Cody's true change in FTP.

<u>Self-Regulated Learning:</u> Cody primarily utilizes *seeking social assistance, seeking information, organizing and transforming,* and *self-evaluating,* and this is highlighted in how he defined study skills,

> If you have study skills, I think it means that you know A) how to get information, B) how to interpret information, and C) how to understand and commit that to a long-term memory, so not only, "Yeah, I can recall this. I recall that this, this equals this. I can understand why that is." (Cody, Interview 1)

He only uses *changing the study environment* by engaging in class. Cody believes using study skills is extremely important and defines them, "If you have study skills, I think it means that you know A how to get information, B how to interpret information, and C how to understand and commit that to a long-term memory, so not only, 'Yeah, I can recall this. I recall that this, this equals this. I can understand why that is.'" To check to ensure he knows the information (*self-evaluating*), he summarizes in his own words while talking with other students (*seeking social assistance*), and he uses peers to learn by having them explain to him and repeating back (*self-evaluating*). He uses the same skills in all his classes, not just engineering. However, Cody believes practice problems (*organizing and transforming*) are key in engineering (and not in his other courses).

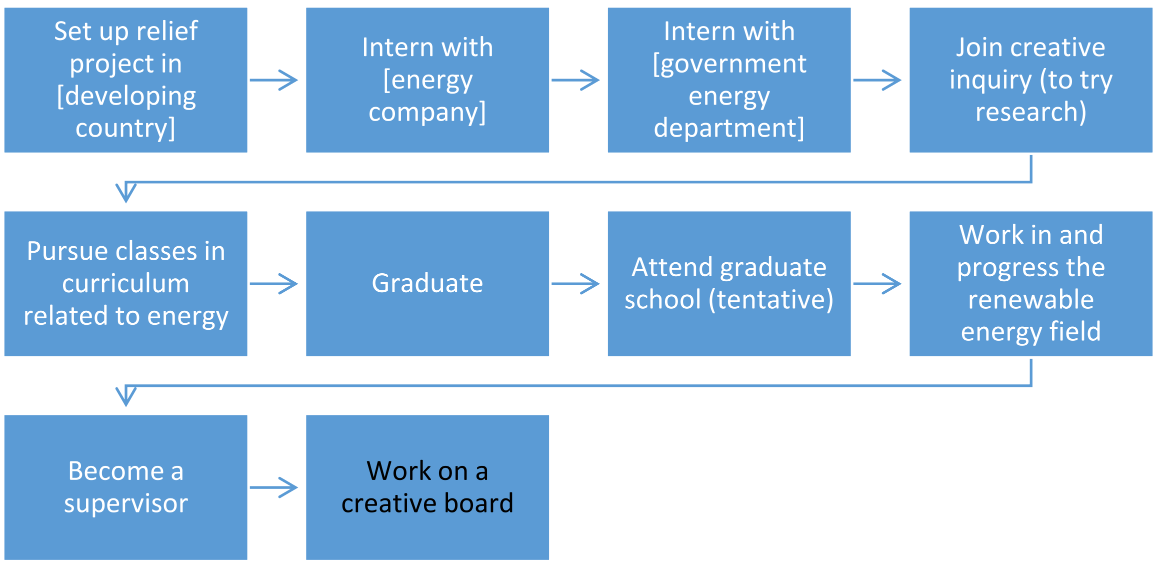


Figure 5.3: Cody's timeline of proximal sub-goals and distal future goal relating his FTP and SRL. Cody is very open and has a long list of well- and ill-defined goals, all leading to his DFCG's.

Connections: Cody sees learning in his engineering program and studying as related to his future goals. For example, Cody is working on a humanitarian effort and feels that the skills he is learning by working on projects with a lot of different people, not just engineers, is invaluable to his future:

> Of course there's stuff in the curriculum, but if you want to learn something, just reach out and learn it… Everybody here, especially, is so helpful with being able to learn something. I just reached out to the head of the CDC and was like, "Do you want to do a project with me?" He was like, "Yeah." There's so many people willing to help that it's really on you to be— You're the only one accountable.

Cody uses his SRL strategies of *seeking information* to support his goals in this effort and overall in engineering. He also thinks he will use these and other skills in upper level courses, such as nuclear engineering where he will need to find data, interpret it, and work with a group. Overall, Cody has a high endogenous PI for his engineering coursework and skills and it drives his self-regulation in these courses, as he sees them useful for later:

> Now, it's kind of like, engineering, I realize it's not just math and science and building blocks and stuff like that. A lot of people will hire engineers regardless of the job, because it teaches critical thinking and being able to break down a problem into parts. I guess I'm pursuing it to continue those as well as it's actually applicable to what I want to do now, so now that I've chosen a career path that involves helping the environment indirectly, essentially, I think that engineering is the best major to go about that.

5.5.2.4 Dana

Dana is a female, international, IE student. Dana originally wanted to be a doctor, and she picked IE by ruling out other disciplines; for example, she did not want to pursue civil engineering as it is hard to find a job in her home country. She considers engineering-related jobs as a way you approach problems, in a scientific, methodological, and analyzing way. She realizes she does not know much about what happens in an engineering job and is trying to get an internship to help her learn. She sees herself using what she is learning in her job all the time and staying in engineering for the duration of her career. Dana has a short, ill-defined view of the future and cannot see past finding a graduate school. Up until now, she was very involved in sports. While she knows she wants to have a family and get a job, likely in industry, she is unsure about what kind of job. She wants the job to be "satisfying" and is not concerned with being important or a leader in the company. She also is considering moving back to Italy and thinks she will end up there in 10 years. While her view may be ill-defined, she feels she can be anything in the future: “I think I can seriously ... I can be everything. I just learned that whatever the others do, you can try to do it. If I want to do something, I think I would be able to." At this point, Dana’s DFCG is graduating (see Figure 5.4).

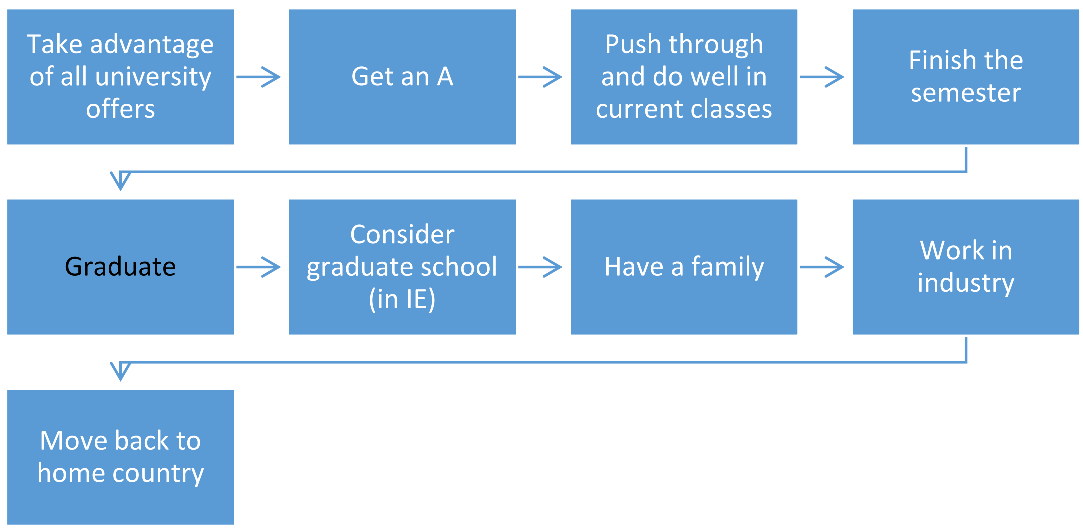


Figure 5.4: Dana's timeline of short-term proximal sub-goals, DFCG of graduation, and potential distal future goal of working as an IE in industry relating her FTP and SRL.

Dana sees her current experiences as important for her future and has a strong sense that what she is doing currently will impact her future but does not have current or short-term goals that are created/driven by the future she sees. Dana considers her main goal at this time to take advantage of all of the opportunities at the university, including research and studying. Overall, Dana can see skills (determination, collaboration, etc.) as more important than the actual material to her future (graduate school and engineering). She views her lab work and coursework related to software as important for her future and the engineering profession. Affected by her unfamiliarity with the field, she feels the basic material is relevant to her future but does not see the connection between the material she is currently studying and the field:

> I think this is just the basic stuff that we are learning. Of course we don't know the practical, because work I think is going to be much different than what we study, but if you don't know the theory you're not going to know the practice. This is like a huge base.

Dana often makes decisions last minute and does not plan, except very short term, for the future; in fact, she decided to come to Clemson within a two-week timeframe after offered a position on a [sports team]: "Everything can happen. It is not limitation to that. It's just…when you have an opportunity, I think it's on you, deciding when acting or not. I just decide to take this opportunity and try." These views of learning and life as an opportunity may be an international trait that is culturally-driven by her home country and ties. However, these provide a stronger picture of Dana's FTP. Dana clustered as a Cake Cone based on her survey scores in the fall and either a Cake or Sugar in the spring. Her survey scores in the spring are unlike a typical engineering student (with a high FoP but lower F scores), which may be related to her international status and the value she places on learning. Qualitatively, Dana is a Cake Cone in spring.

Self-Regulated Learning: Overall, Dana believes studying is a person-to-person thing, and she feels studying for engineering and non-engineering courses is the same (but is currently enrolled in all engineering courses). She hopes to learn, grow as a person from the learning process, and gain personal satisfaction. When studying, Dana primarily highlights important information and creates diagrams (*organizing and transforming*) and is a self-proclaimed "visual person" and uses *organizing and transforming* in this manner (writing using large texts, creating diagrams, making review sheets, visualizing the material in her head, and rewriting material (also *rehearsing and memorizing*)). On a regular study night, she will draw a visual aid several times (*rehearsing and memorizing*) and test herself to ensure she remembers the material (*self-evaluate*). She thinks she has learned something when you are able to do well on the test but also if you remember the basic information. Dana sees knowing how to problem solve as the most useful study skill for her career (*organizing and transforming*).

Connections: Dana uses goals as motivation, encouraged by her endogenous PI. Dana is considering graduate school but is unsure about her future. She uses her short-term graduation and grade goals to motivate her self-regulation. She views studying and her time at the university as an opportunity: “Whatever you can learn and take advantage, of course, is going to be something that you can use in the future." She also believes studying is essential to her future. “[Learning] is the base of everything. You learn something that ... I actually have no idea how can… I will use, because I don't know what I'm going to be. It's hard to say, but I think I will just use as a base to construct something." This is not commonly something that American students say. However, Dana also has a goal of achieving an A in each course, as it shows she knows the material and has learned it, so she self-regulates in her courses.

5.5.2.5 Erin

Future Time Perspective: Erin is a female, Caucasian BME major who wants to go to medical school and be a doctor, her DFCG, with BME as a backup. She also considers it very important for her future to have a family and be a good mom, which causes conflict in her future goals. Erin has conflicting ideal and realistic futures within medicine. She describes her ideal self as balanced and happy, and discusses having a family and balancing her career as important goals in her future. She self-identifies as career driven but she labels her most important goal as having a family. Her goals (and path, see Figure 6) are very well-defined until she hits a divergent set of paths once she has to select her specialty in six years (3rd/4th year of med school), family pediatrics (realistic) versus OBGYN (ideal), showing a Waffle Cone FTP:

> Likely family care, family pediatrics just because my desire to have a family and a balanced life is so strong. I think the more I talk with people and the more I talk

> with females in medical professions, it seems very difficult especially in the early years to have a family. Taking steps to make that easier is probably where I'm going to end up.

Currently, Erin has conflicting futures and showed a quantitative shift from Cake to Waffle Cone between the fall and spring semesters. Erin believes the family pediatrics position will give her more flexibility and be more conducive to being a mother She also realizes that her desires may change through time as she experiences medical school and advances in her career. Erin’s career goals, including her DFCG of becoming a doctor after attending medical school, are shown in Figure 5.5. Further interviews and data collection about Erin’s FTP may highlight her shift in FTP.

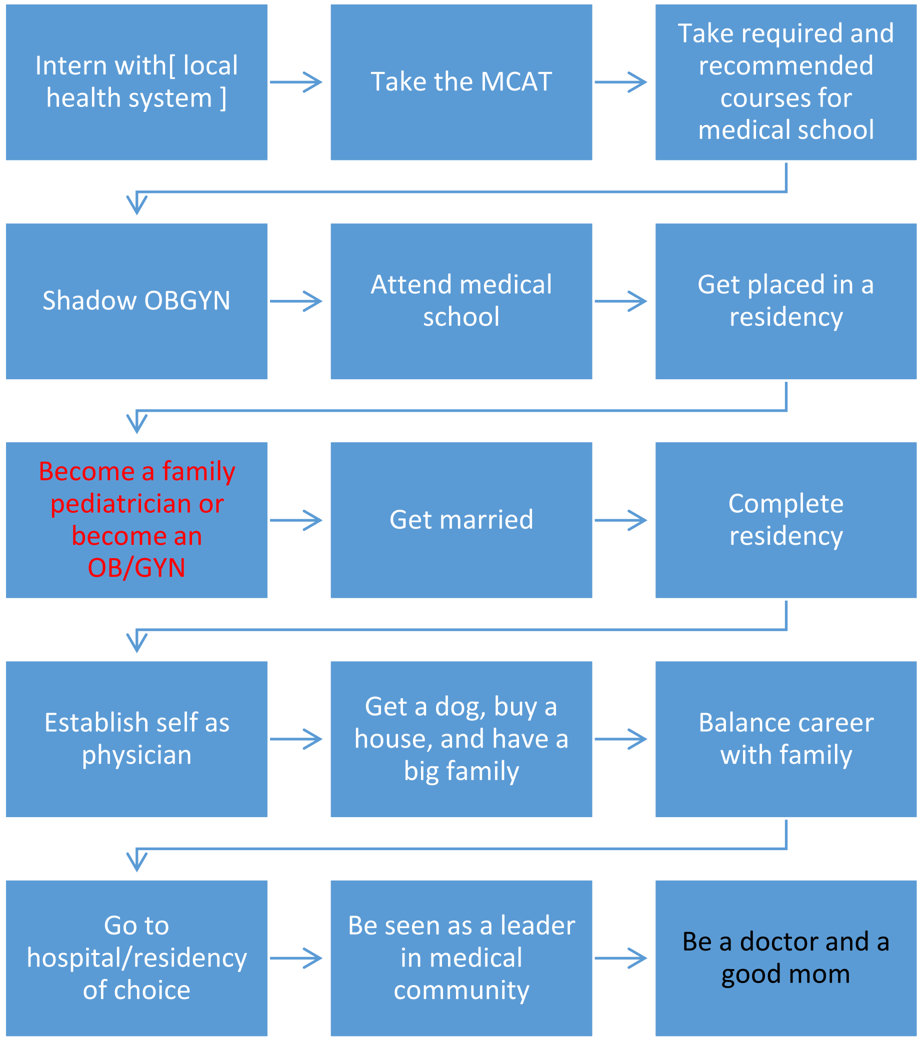


Figure 5.5: Erin's timeline of short-term proximal sub-goals and distal future academic goal of becoming a doctor (in black) in some sort of family medicine. Erin has conflicting ideal and realistic goals (in red) after she has to select her specialty.

<u>Self-Regulated Learning:</u> Erin learned how to study through experience in high school, her sister, and the campus learning center. Erin sees engineering as more problem-based than other disciplines/courses and utilizes *planning and goal-setting* to get through her work: to-do lists and adjusting this list daily. For engineering, Erin works a certain amount of problems. For non-engineering, in contrast, Erin chooses an amount of material to read. Erin uses *organizing and transforming* (drawing, visualizing) and taking breaks and selecting an ideal location while studying (*changing study environment*) for all of her courses. Erin described her approach to studying for engineering as, "[considering] a problem after you've solved it and trying to re-explain what it was asking you and why it was important. I think that's a skill that can be specific to engineering" (*organizing and transforming*, *rehearsing and memorizing*, and *self-evaluating*: selecting the main idea, reorganizing, using the problem solving process, summarizing in your own words, and reviewing/repeating material).

Connections: Erin has an interesting perspective on her motivation behind learning and using study skills, driven by her DFCG and thus her proximal sub-goals related to becoming a doctor:

> You have to really decide to do it, because I don't think they're easy things to convince yourself to do. Most study skills are not something we would naturally do… I think for most of us, you wouldn't sit an extra 10 minutes at the end of every assignment just to re-consider everything. If it's a skill and it's something that you want to do, then you have to force yourself to do it. And then it becomes habit after a while.

Erin sees the value of her engineering degree as a doctor. She also feels she has strong critical thinking and creativity skills, which will lend themselves to engineering and being a doctor. Erin thinks problem-solving will help her in the future. She took a waitressing job because she had "idealized" it and thought it would help with her communication. She believes this will build her skills more for family pediatrics, while compassion is more necessary for OB/GYN. For a Waffle Cone FTP type, Erin has a high endogenous PI. Her PI appears related to her future in the medical career and her goals of taking the MCAT and attending medical school. For example, she sees biology material as related. She thinks her major courses will be more related and important than her non-major: "I *get* to take anatomy next fall." Thus, Erin self-regulates to learn the material, succeed in the MCAT, and prepare for her future career goals.

5.5.2.6 Faye

Faye is a Caucasian, female, IE major in her eighth semester. Currently, Faye is working to graduate and get a job out in the real world, so her focus is on short-term goals. Faye decided to pursue an engineering major during high school. She enjoyed math and felt she was a strong science student. Others told her she could succeed as an engineer, and Faye felt the pay for engineers was appealing. She defines an engineering-related field as: "Definitely like being in industry and like having a title ‘engineer,’ or like being a professor and teaching it, I would count that..." She wants to be in such a profession her entire career. Specifically, her plan is to try out IE in the workforce and "see if I enjoy like what field I'm in and if not just go back to like pursuing education." Ideally, she would like her company to pay for her MS and then decide whether to return to work or continue on to pursue a PhD. Additionally, Faye wants to be an IE professor and support and teach students as they come into the major. She developed this idea of her future through her experiences with her family members (who are teachers), professors she has had in the past, and her experience as a resident assistant in campus housing. Faye is sure about wanting this future and feels that only a major event would make her change her mind. Eventually, Faye would like to become a supervisor of others in a position such as an endowed chair for a university department. Faye's main short and long-term goals are in Figure 5.6. Faye does not want to do anything boring, such as collect data or sit at a desk from "9 to 5."

Faye primarily believes her major courses, specifically those labeled as IE, are useful for her future; for examples, she believes her course about Six Sigma, involving production planning, layouts of work space, ergonomics, design of small spaces, etc., will be particularly useful. Faye believes appropriate communication, time management, the ability to work in a group and work independently, capability of working with others from different backgrounds, leadership (learned in sorority as chair for committee), empathy, and the ability to act quickly are important for her career and in an engineering-related profession. She believes she will use what she is learning in her major in industry as long as she is working and even when she becomes a professor. However, if she ends up as a high school instructor, she is unsure if the material would be applicable, but she prefers the university position over high school. She sees her education playing a large role in her future as her classes will be relevant to her position, and any position that is engineering-related. If she ends up teaching, she believes she will be able to teach those classes due to the coursework she has taken.

Faye's quantitative MAE score placed her as a Waffle Cone FTP type both in fall and the following spring, and Faye has a clear path of goals but is thinking more short-term at

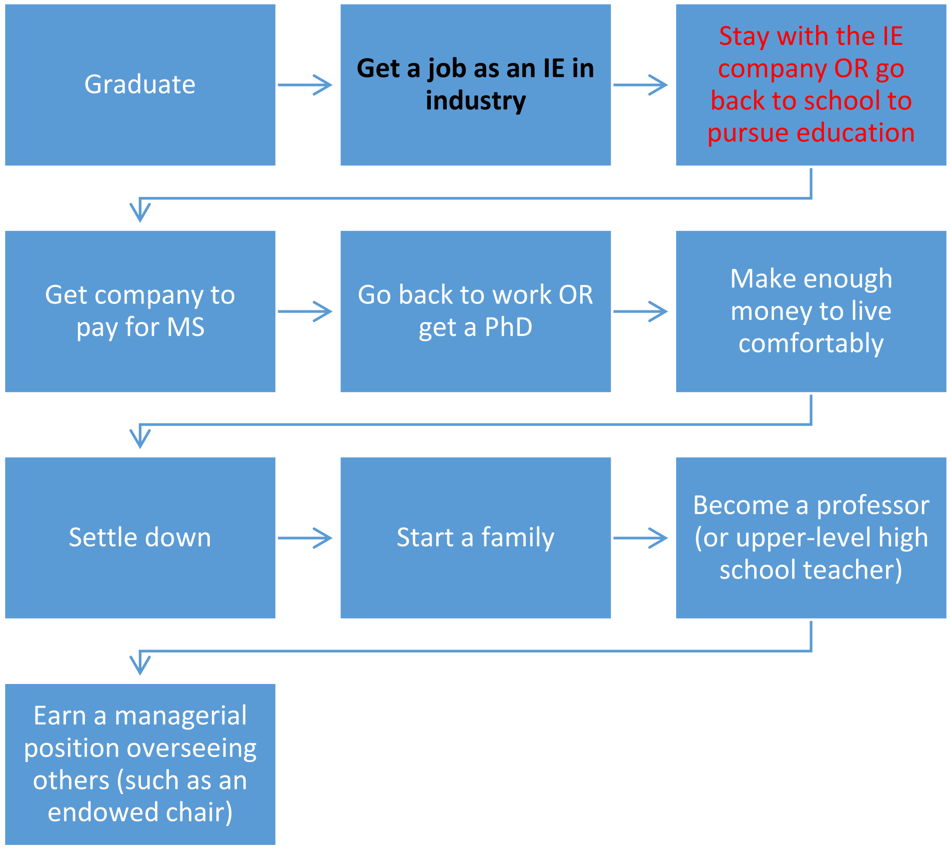


Figure 5.6: Faye's timeline of short-term proximal sub-goals with two DFCGs: short term DFCG of getting a job as an IE in industry and tentative long-term DFCG of becoming a professor.

this point, likely due to her impending graduation. Unlike the second-year students, she has to make a choice very soon about graduate school and a job. Her current Waffle Cone FTP type is likely due to her insecurity about how much she will enjoy industry and impending decision about becoming a professor. She ideally would be a professor but she noted she will most likely try industry first. For her first MAE survey, the lower PI score (3.67 out of 7), compared to her high PI score of 5.6 (out of 7) in the spring, may be due to the importance that Faye placed on the MSE course and material, as the survey was context-specific. Faye wants to be a professor for lower-level IE courses, and the MSE material may not be applicable to that position. Faye has low PI in regards to her MSE 2100 course but high PI for her reflected IE course, and PI had a significant contribution to the clusters (see Chapter 4). Additionally, Faye had medium F scores on both MAE surveys (4.5 in fall, 4.25 in spring), likely due to her conflicting ideal and realistic future career goals.

Self-Regulated Learning: Faye feels she did not need study skills, which she defines as "the ability to retain but also learn information and not just memorize it," in high school and had to develop them in college. Unfortunately, her first year she mostly utilized *rehearsing and memorizing* strategies, which she feels did not work out. She learned her current skills through trial and error (*self-evaluating*) and workshops provided through the campus learning center. She believes the definition of study skill is the same for her engineering and non-engineering courses and believes that learning should be emphasized for engineering. However, Faye utilizes study groups to study, and believes they are vital as an engineer to build communication and group work skills. She also believes building relationships with her professors, TA's, and other students as beneficial and sees this as the biggest difference in studying between her engineering and non-engineering coursework (*seeking social assistance*). Faye checks her answers to ensure she has learned the material and believes it is easy in engineering to *self-evaluate* because there is a right or wrong answer. She also talks to her roommates, who are also engineering majors, to figure out if she has learned what she needs (*seeking social* *assistance*). Faye uses several of the SRL strategy themes to her benefit in her engineering and non-engineering courses but for her engineering classes, she uses study groups, seeking assistance from her professors, and organizing and transforming the most. In particular, Faye uses her professors for her major courses. Faye thinks reaching out to other students is useful in current courses and for future semesters, and she said,

> In my engineering courses, you kind of just move along with the same group through everything. I have kids from like my sophomore beginning-level industrial engineering classes that like I still have in my classes today. That really helps, just like moving as a unit through the group. Learning the course as a class instead of just trying to do it on your own.

Faye uses other skills, such as *changing the study environment* (uses learning center to study), *planning and goal-setting* (plans study breaks), *self-monitoring*, *organizing and transforming*, *reviewing records*, and *rehearsing and memorizing* (Chegg, Quizlet).

Connections: Faye’s current self-regulation is driven by her goal of working in industry but her timeline also encompasses proximal sub-goals for her professor position. She classifies her classes in three ways: IE, non-IE engineering classes, and general education (non-engineering) classes. Faye's internship helped clarify what material, IE and non-IE, would be valuable to her in the future. She believes IE courses are useful for her future and she needs to be able to apply the content in her career. Non-IE engineering classes are useful only for the FE exam. Faye self-regulates enough only to do as well enough as needed on her exams. She explained, "Gen ed is mostly just get through the class, that's it. Don't really like approach it as if I'm going to need it for longer than that semester." While Faye self-regulates in her engineering courses as she believes they are valuable for later in her career, she only regulates enough to be successful for exams in her non-engineering, general education classes. Faye's high PI for her engineering courses help her self-regulate to succeed in the courses and she views the importance of her courses differently than typical engineers. If she doesn't believe the course is important, and is only helpful for the FE, she tries to earn a C and "moves on." Because Faye believes she will become an engineer and believes working in groups is vital, she self-regulates in her courses utilizing study groups. When she believes a course is important (or not) for her future, it also affects her class attendance (*study environment*) and her use of *seeking social assistance*.

Faye is primarily grade oriented; however, for her IE coursework, she realizes the importance of knowing the material well enough to apply it outside of school. Faye said,

> For my IE classes, it is to like learn the material and then hopefully get the good grades, too, but definitely learn it so I can apply it outside of school. My non IE engineering classes, like material science and like statics and stuff, it's just like, okay, learn this stuff so you can get through whatever you need to use it for, whether it's like just that class or if I do take the FE. I guess it's like less intense need to learn and understand it.

Her high endogenous PI for the skills she is learning and for her IE courses helps her self-regulate in the present as she believes the content will be important for later in her career:

> I think just the ability to like learn anything in any kind of situation, just kind of, like, apply it to learning on the job or like stuff like that, because I mean in the real world, memorization of facts isn't going to get you anywhere, or as far as it could if you learn the material. I hope the ... just being able to use that and apply it to any aspect of life, if that makes sense.

5.5.2.7 Greg

Greg is a Caucasian, second- year, male MSE major. Greg had an experience at a summer camp for MSE in high school which piqued his interest. He has seen his family be successful, modeling what he needs to do, and he has always liked math and science. Greg wants the flexibility of changing paths if he finds something he is interested in but is currently pursuing glasses and ceramics in MSE and a position in industry. Greg knows that he doesn't know enough to be absolutely sure and is giving himself opportunities to learn more. Greg has always planned to do something engineering-related, "…more of working with what you're making. Business is more of selling what you're making and working with other people." Greg's goals are ill-defined in the long-term but he can see out about 10 years. He does know he wants a career and does not want to attend graduate school; he wants to have gained experience and be a leader in the company. He is avoiding every position besides becoming an engineer, and he wants to make a comfortable living to support a family.

Greg has a high endogenous PI for all of his coursework. He thinks psychology and other non-engineering classes are not specifically related to his career but the concepts potentially are. Greg sees a direct connection from his coursework to his future, such as statics and organic chemistry II (differential equations and metrics testing lab depend on the company); he recognizes not needing to know details but that overall knowledge is important. Greg believes the following skills will be important for his future: organization, time management, hard work, seeking help, being studious, studying in a way that makes sense to you, and being personable.

Greg has a strong sense of connection between his present and future and his future goals impact decisions he makes in the present. For example, Greg secured an internship with a steel company for the summer to learn more about the field and gain experience. Though the company is not related to glasses and ceramics, he believes the experience gained is similar, as the processes behind the manufacturing are analogous. Also, he thinks this could help him decide a path to stick to or leave glasses and ceramics. He also plans to obtain a co-op with a glasses and ceramics company, for the next spring. Greg explained,

> From the intro to MSE class, steels, and ceramics, they're actually fairly similar, it's just, you have like your main metal element or whatever, and then you're putting stuff in there, and ceramics, you're just putting different elements together, so I guess... the same like broad, general processes so I'm still learning more about material science, it's just not specifically about glasses, and ceramics right now. But I think that this will give me a good experience to make sure material science is the right field, and then I can specify, more of that after this internship I hope.

Finally, Greg believes that Clemson, as a nationally respected institution with extensive resources (e.g. career fair) will help him get to where he wants to go by teaching what he needs to know for the future.

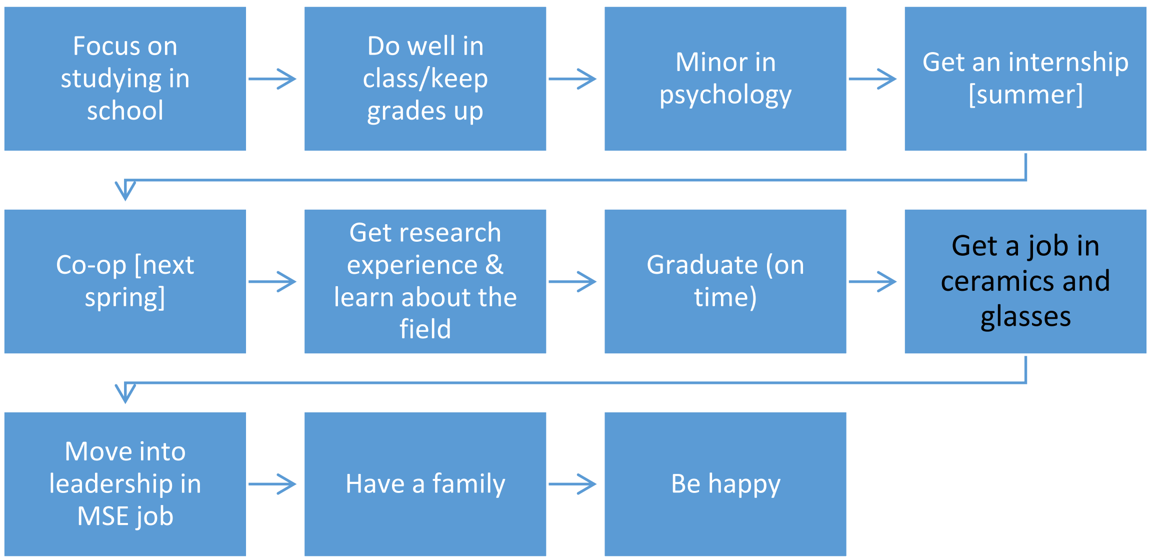


Figure 5.7: Greg's timeline of short-term proximal sub-goals with a DFCG of getting a job in ceramics and glasses (field in MSE).

Greg clustered as a Sugar Cone FTP type in the fall and Cake Cone FTP type the following spring based on his survey scores. As Greg is an MSE student intending to work in industry in a related career path, his MAE results are likely valid for fall; conversely, he reflected on a civil engineering (CE) course in spring, which Greg may not see as relevant. Though Greg is unsure about everything available in MSE, his goals are clear and he sees a direct connection between his future and present and vice versa. Qualitatively, Greg appears to be a Sugar FTP in the spring, in contrast to his spring survey results.

Self-Regulated Learning: Greg uses varying strategies for his engineering and non-engineering courses. Overall, he uses *planning and goal-setting* (e.g. plans breaks) for both. However, for engineering he uses primarily *organizing and transforming* strategies such as pulling out concepts from material, “understanding” over memorizing, learning how to do a problem, and connecting the material. Greg is more motivated to self-regulate in engineering courses, which he finds relevant to his goals. For non-engineering, he uses more *rehearsing and memorizing* strategies. Greg, while seeing the value in working in groups, is an independent studier: "I like to just sit down and figure out what I don't know and work on that instead of figuring out what other people don't know.". Greg has learned the material and used his study skills effectively if it reflects in his tests and quiz grades; he also considers studying a success if he gets asked about the material later and still understands the principles. Greg says, " I feel like I've figured out what works best for me over these past semesters in college and use those for each class. I figured out what kind of class it is; do I need to do the text book readings or do I need to do example problems. And I’ll use what study skills I know for that type of class."

Connections: Greg draws on his future goals, as seen in Figure 5.7, to motivate his SRL in the present: “I feel like I've set myself some pretty high goals for what I'm trying to accomplish, and how I'm trying to accomplish it, so those study skills, the better I do with studying those study skills, the more likely I am to reach those goals. So if I just didn't study and I had like a .2 GPA, I would not have landed an internship." He is very grade driven but has a high endogenous PI for his engineering coursework. He sees value in truly understanding the material for later and thinks his understanding is reflected in his grades: "I feel like my goals are based on what grades I get in the class, but how I do in the class depends on if I understand the material, and how I'll be able to do in future classes, so studying is going to give me the grades which is going to help me achieve the goals."

5.5.3 Quantitative and Qualitative Results

In Table 5.3, the qualitative cone type according to the interview data analysis results is compared to the proposed quantitative cluster/cone type according to the composite scores from the MAE survey distributed in the spring semester.

Table 5.3: Comparison of seven interviewed students' quantitative and qualitative results

Name	Course	Major	F	PI	FoP	Quantitative Cluster	Qualitative Cone
Anna	Mid-year MSE course	BME	3.25	4.8	3	Waffle	Waffle
Barb	Mid-year BME course	BME	3.75	4	3	Waffle	Sugar
Cody	Mid-year ME course	ME	6	5.8	1	Cake	Sugar
Dana	Mid-year IE course	IE	4.25	5.6	6.5	Sugar	Cake
Erin	Mid-year BME course	BME	3.75	5	3.5	Waffle	Waffle
Faye	Mid-year IE course	IE	4.25	5.6	4	Waffle	Waffle
Greg	Mid-year CE course	MSE	6.25	5.6	2.5	Cake	Sugar

5.6 Conclusions, Limitations, and Future Work

5.6.1 Case study participant selection and themes

The study saught to select three case studies, one of each FTP type, from seven participants. Theoretically-based and information rich cases must be selected to support a generalizable model about the connections between engineering student FTP and SRL strategy use. Ideally, three students would be selected who vary by FTP across all time points; however, the only consistent Waffle Cone FTP type (Faye) was a graduating senior who waited to take her MSE course until her final year. Her data would not add to the theoretical framework for second-year engineering students as the data would be for different time points in the student experience at the university and, therefore, not comparable. Similarly, Dana, as an international student, does not fit the population of interest and would not add to FTP theory about American engineering students. Interestingly, the majority of the participants changed FTP Cone type during the school year, showing that the second-year in engineering as developmental for student FTP. When comparing each of the participants, several significant features are elicited, such as changes in FTP and inconsistency (discussed below) of the MAE survey. Specifically, there are three participants who started as distinct cones and then all merged into the same cone. A selection of students of this nature will allow for a comparative approach for this multiple case study. The SRL and connections between SRL and FTP in the fall will be able to be compared for different FTP types, and then the SRL and connections in the spring semester will be able to be compared through the same FTP lense. A selection of this type will allow for a richer and closer comparison of data, further supporting the validity of a model.

The quantitative and qualitative data collected and analyzed provided enough evidence for the selection of case study participants: Barb, Cody, and Greg. These three students were selected as each began the fall as a quantitatively separate FTP type: Waffle, Cake, and Sugar respectively. After the survey and interview in the spring semester, Barb had changed from Waffle to Sugar FTP type and Cody merged from Cake into a Sugar FTP type student. Additional information provided by these two students also verified their clustering placement from the fall. At that time, Barb was debating what used to be her ideal future (anesthesiologist) in light of a bad experience in the summer; during a winter internship, she changed her career goals after a successful and interesting internship with a pharmacist. Both of these paths provided her the means to enter the medical field. Similarly, Cody has always had an interest in energy and aerospace; in the spring he is much closer to deciding what he would like to do and has selected a DFCG: being on a creative board. He now is struggling with deciding which path to get there, but his DFCG is helping him create proximal sub-goals to lead him down that path. Exploring Cody's development and FTP further will elucidate this transition and the fine line between possible student cone types. Finally, Greg clustered as a Sugar FTP in the fall and qualitatively appeared as a Sugar in the spring. A second interview and journal data will help complete the picture of these three students and their FTPs, SRL behaviors, and any connections between the two. While the survey and data from the first interview provided a limited view of the connections between FTP and SRL in this chapter, further data collection and analysis, including a second interview, will provide significantly stronger evidence for connections. This will be explored in Chapter 6.

5.6.2 Themes related to FTP, SRL, and their connections

Additional themes related to student FTP, SRL, and connections between the two arose during the analysis of these seven engineering students. Those themes are:

1) Students are more likely to spend time in office hours or reaching out to their professor if the professor is teaching a major course, which is considered *seeking social assistance* in terms of SRL. "I guess the difference between the gen eds and the engineering is like the

relationship with the professor because I'm like okay, I'm probably just going to see you just one time in my life." –Faye

2) Students are open to change, and their DFG is influential in developing and updating their DFCG: "Realizing that it's not fun. I've been pretty much on the border between working with energy and aerospace for a little while. This summer, I interviewed with Boeing and I interviewed with Duke and I wasn't sure which I wanted to go for and ended up, well, Duke, like I get to stay here because I'm working at the county plant, and so I don't have to like worry about subleasing out an apartment that sucks anyways and this is something that- This is my number one going in. Nuclear energy is what I want to do. If I realize that that's not what I want to do, then my goals are kind of going to change, but I'm pretty flexible with whatever happens." –Cody

3) Students that were not Sugar Cones, who had very short views and goals set into the future, still self-regulated and were motivated by proximal sub-goals, such as those related to internships, graduation, etc. They generally set some sort of "short-term" DFCG, such as graduation, that helped them set proximal sub-goals in the shorter-term. For example, Dana, a Cake Cone student, set a goal of graduating as her DFCG. This short-term goal motivated her to self-regulate in her courses.

4) All of the students except Barb spoke of utilizing *organizing and transforming* SRL strategies for engineering-related courses and material. These strategies were less likely to be utilized for non-engineering courses. Examples of these strategies are:
    a. "…drawing diagrams for physics and statics and those kind of classes." –Anna
    b. "I think specifically for engineering is going to be that ... being able to verbalize it. There's a lot of tough concepts and a lot of what we do is, like I said, breaking down a problem and assigning a model to it. I think if you can't understand it, if

you can't walk through it and be able to break it down and assign it and assign different problems to it, then you're not going to be successful in engineering." –Cody

c. "You divide the stuff, so you don't, like, 'Oh, my gosh. I have all this stuff together. What's going on?' If you set up, you divide stuff, it's easier then to see a whole picture." –Dana

d. "Considering a problem after you've solved it and trying to re-explain what it was asking you and why it was important. I think that's a skill that can be specific to engineering." –Erin

e. "I just had an exam this morning where I went back through all the PowerPoints and I compared like what I was able to write in class to like what it actually said on the slides, so I would just like combine both of those things into one set of notes. I felt pretty good about the exam." –Faye

f. "I like to write things down, usually what I'll do is I'll go through my notes and then I'll do a list of the concepts that I need to know, and then, um, a lot of times like for chemistry, what I'll do is I'll write down the beginning and the after and then if I don't understand why it gets there, then I'll go back in my notes, but a study sheet, like a summary sheet really works well for me because I'm getting the broad concepts. If I understand those broad concepts, how it gets from A to B and then not on the study sheet but, then in my head I know why it gets there, it really helps me." –Greg

5) Additionally, most of the students thought that study groups in engineering are important to help with course material, to make *seeking assistance* easier, to serve as a form of *evaluation*, and to build group work skills for a later job: "Normally I'm studying with

other people in groups… Partially, just the social aspect of it. Also, if I don't know the answer and maybe I can't find it online, they might know it." -Barb

5.6.3 Limitations

The FoP survey items in the MAE appear to not fully measure the FoP construct, and more items may be necessary. Greg surveyed in spring with a low FoP, thus classifying him as a Cake Cone FTP type. However, during his interview, Greg appears to be a Sugar Cone student. Additionally, Barb additionally appears to be a Sugar Cone FTP type in the spring, with clear discussion of how her future impacts her present and vice versa. However, Barb's FoP is medium (or even low) for the fall and following spring surveys (3.5, 3, respectively). The relevancy of chosen reflection courses may have had an impact, so removing the context-specific items in the future may show different results. Likely, as this construct currently has two items after an EFA for this population, an additional item or two should be added to address all possibilities of the theory. Similarly, FTP appears to be highly contextual and the selection of a reflection course is important. When Faye, IE major, reported on an MSE course in the fall, she fell into the Waffle Cone FTP type with a medium PI (3.67 out of 7). Her F score remained similar (from 4.5 to 4.25 out of 7). However, she reported a very high PI score (5.6 out of 7) in spring. This high PI score in spring was likely supported by her reflective course selection, as she is an IE major, and she reflected on an IE course.

5.6.4 Future work

A future interview would be beneficial to find out more about the timeline and future perspectives of these students. A single interview provides a limited view and context for goals. For example, Cody disclosed a large amount of information and a long list of goals in his 60-minute interview. The time with him was not enough to figure out his preferred timeline for each of these goals, how sure he was about obtaining each goal, or the value he placed on each goal (by itself or in relation to his DFG or DFCG). Additionally, more information about the self-regulatory habits of the participants in regards to obtaining proximal and distal future goals may provide insight into student FTPs, SRL, and the connection that FTP plays in the self-regulatory habits of students in regards to learning. Additional information about their SRL, specifically in the context of different classes, would also be beneficial in this regard.

CHAPTER SIX

6. A Sequential Explanatory Mixed Methods Study with Case Studies

6.1 Introduction

This chapter focuses on evidence of connections between undergraduate engineering students' perceptions of their future and their SRL strategy development and use during the second year of their undergraduate career. Development of these SRL strategies, in particular sub-goaling as described in Chapter 1, is important for their success[63,64,67]. This research seeks to answer the following research questions by fully describing the types of SRL strategies that undergraduate engineering students report using and adopting, elucidating connections between their FTP and use of SRL strategies, and exploring goal-setting as one of these connections. This research will highlight overall SRL strategy use of undergraduate engineers from multiple engineering disciplines. Additionally, this research intends to explain the experience of task-specific SRL strategy use for students within FTP cones.

RQ1: What SRL strategies do engineering students utilize?

> RQ1.1: How do engineering undergraduates adopt SRL strategies in a course required for their major?
>
> RQ1.2: What SRL strategies related to task-level sub-goaling do engineering undergraduates utilize?

RQ2: What are the connections between students' FTPs and their use of task-specific SRL strategies?

RQ2.1: How do students' FTP attributes relate to their use of SRL strategies?

RQ2.2: In what ways do the SRL strategies differ among FTP types?

RQ2.3: How does sub-goaling connect students' FTPs and their use of SRL strategies at the task level?

6.2 Methods

6.2.1 Participants

Students enrolled in a second-year materials science and engineering (MSE) course were invited to participate in this study in the fall, with approval from the instructor for data collection at multiple time points. This course and the student participants are described further in Chapters 4 and 5.

6.2.2 Data Collection

While enrolled in the MSE course in the fall, participants (N=97) completed the Motivation and Attitudes in Engineering (MAE) survey (described in Chapters 1, 3, 4, and 5), attended the SRL "Study Cycle" intervention (described in Chapters 1, 2, 3, and 5), and journaled about their study skill use during each two-week period preceding their three course exams (N= 96, 73, 76, respectively). All students received course credit for completing the journal entries. Students' grades in the MSE course were collected to compare to the journal entries as a validity measure. In the following spring, the MSE students were invited to complete the MAE survey and attend an interview about their FTP, SRL strategy use, and connections (Interview 1, see Appendix E). Nine students completed the survey, and seven of the nine attended the interview. Case study participants were selected (see Chapter 5) (N=3) and invited that same semester to attend a second interview, further elucidating FTP, SRL, and the connections between the two, with a focus on goal-setting (Interview 2, see Appendix Q). The second interview protocol was created based on theory, expert advice, previous pilot work for this research, and edits from a trial of the protocol. The data analyzed for the three case studies in this chapter include the two MAE surveys (fall semester, following spring semester), MSE journals (fall semester), MSE course grades (fall semester), and the two interviews (following spring semester). For a full timeline of data collection and sample sizes, see Chapters 4 and 5. Incentive cards ($20) were provided to interview participants. Students additionally received a ($10) incentive card for participating in member checking, or participant review of analysis and interpretation[201], after analysis of the case study data.

6.2.3 Mixed Methods Sequential Explanatory Research Study

A mixed methods approach with a multi-phase sequential explanatory design was conducted to analyze the relationship between student FTP and SRL strategy use through exploration of sub-goaling. This study utilized two sequential mixed methods phases (Phase a and Phase b), and Phase b was the priority. In Phase a, the two MAE surveys and Interview 1 data were analyzed and case study participants were selected (see Chapter 5). Then, all case study data were analyzed separately in Phase b. The integration of both sets of data occurred at the interpretation phase[202]. Figure 6.1 shows Phases a and b including the data collection, analysis, and interpretation stages for the qualitative and quantitative data in the study. This chapter discusses Phase b, the embedded case studies. We use the case study data to "characterize individuals along certain traits of interest related to the research question" (p. 178). This type of characterization in a sequential explanatory design is primarily utilized when the first phase is used for participant selection, which is true for this study.

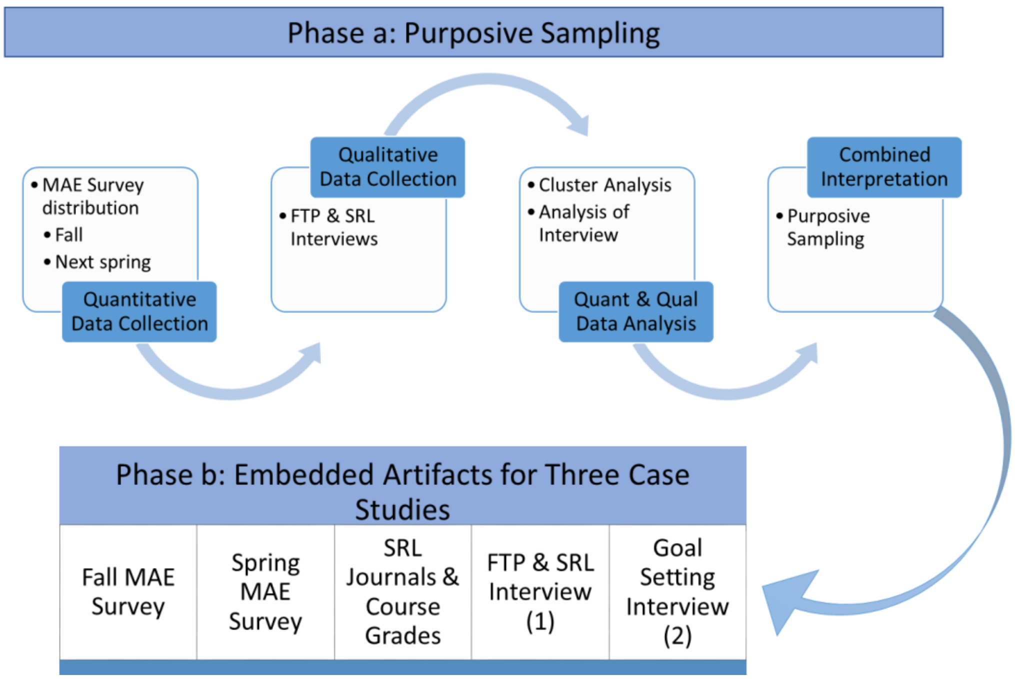


Figure 6.1: Multi-phase sequential explanatory mixed methods design with two phases. The figure depicts the data collection, analysis, and interpretation stages of the qualitative and quantitative pieces of each phase.

In Chapter 5, three case study participants were selected based on theoretical and information-rich cases[203]: Barb, Cody, and Greg. The selection was based on their FTP type, determined through quantitative and qualitative data collected at multiple time-points through multiple data collection methods: MAE survey (quantitative FTP) in the fall and the MAE survey (quantitative FTP) and Interview 1 (qualitative FTP) early the following spring. These three participants were selected as they appeared to have distinct FTP types in the fall semester and then seemed to all merge into a Sugar Cone FTP type in the following spring semester. Further data collection illuminated changes and highlighted the connection between FTP type and SRL.

To form the boundaries of the cases, the FTP type served as an environment, setting, and framework within which students' SRL strategies and interactions between their FTP attributes and SRL strategies were documented. Qualitative and quantitative data analysis provided the foundation for the understanding of the case studies. All case study data is listed in Figure 6.1. A cluster analysis was utilized in Chapters 4 and 5 to classify the FTP of the case study students. Additionally, the first interview for each participant was analyzed using directed content analysis[147]. During Phase b, the three journals from the MSE course and the second interview for the three students were analyzed using directed content analysis[147]. In this approach, definitions and examples of codes are created; transcripts are deductively coded; and categories are refined and revised based on the data. Thus, theory is used to initially create categories for the codes, simultaneously allowing for emergent codes. This type of coding is often utilized to validate or extend an existing theoretical framework, and as the theories in this research are being extended into engineering and to determine a connection between two theories, this approach is appropriate. The three journals and two interviews were coded based on the Self-Regulated Learning Interview Scale (SRLIS) framework[63,67] (described in Chapters 1 and 2), and the two interviews were additionally coded using the FTP cone model[36,40,50] (described in Chapters 1 and 3), allowing for additional FTP codes (such as characteristics for contingent and non-contingent paths[57,149,204,205]) to emerge from the data. The constant comparative method[206] was utilized during data collection and analysis to move between different pieces of data to find consistent information and themes within the data. A logic model[197], a series of boxes and arrows showing the course of events for a participant, was created for each case study participant. For the cross case analysis, data was compared across theories, constructs, codes, and logic models to identify persistent themes and create a more generalized logic model.

The quantitative MAE survey data and qualitative interview data collected at the same times were mixed[207] and considered during the interpretation phase: the MAE survey in the fall semester with Journal 1 and the MAE survey early the next spring semester with Interview 1. The FTP of each participant was also considered at and compared across each data collection time points, whether the data was qualitative or quantitative. Although data collection was sequential, only the FTP data was analyzed for participant selection. All other case study participant data, such as the MSE journals, were not analyzed until the interpretation phase. This was done so the qualitative and quantitative data could be considered holistically to ensure a complete picture of each case.

Multiple case studies were used to explore the SRL strategy use and sub-goaling by researching individuals[197], and the bounds of each case were the FTP type of each participant. A multiple case study approach allowed for deep insight into the SRL use of a student from each FTP cone, which helped generate hypotheses about these interactions; these can then be tested through other, perhaps quantitative, means in the future[208]. Qualitative and quantitative data were mixed to "enrich the description of the sample participants"[207] (p. 184); the multiple case studies and cross case analysis included the MAE survey results and journal entries from the fall semester, the MAE survey from the following spring semester, the interview transcripts for each of the interviews, and exam grades from the MSE course. The cross case analysis provided a more generalized model of the FTP and SRL connections of the case study students, which may serve as a theoretical framework for future work[197]. In particular, RQ1 was addressed with the results from the SRL strategy use and adoption from the journals and interviews. RQ2 was addressed through the results of the survey, interviews, and journals, building on the connections between FTP and SRL. The qualitative and quantitative data were analyzed together to provide a more complete understanding of the connection between students' views of the future and their SRL strategies.

6.2.4 Quality in this study

The *Mixed Methods Legitimation Model*[107,108] was considered during the design of this study, data collection, and analysis. Four of the nine legitimation types are relevant to this mixed methods study: *inside-outside*, *weakness minimization*, *multiple validities*, and *political legitimation*. The research minimized *inside-outside* (the extent to which the researcher uses the insider's and outsider's viewpoint) by conferring with other researchers and experts in the field and referring to literature. *Weakness minimization* (how quantitative weaknesses are minimized by the qualitative portion and vice versa) is particularly important in this study as the connections between FTP and SRL have been minimally studied for engineering students. Weaknesses were minimized in this mixed methods study by allowing for rich description of SRL by using qualitative methods for data collection and analysis. Additionally, a quantitative survey allowed the participants'

FTPs to be sorted into relatively homogenous groups for comparison. In particular, *Weakness minimization* was particularly beneficial as the study mixes qualitative and quantitative FTP data, allowing for a full picture of the FTP constructs and also a deep, rich view. Additionally, *weakness minimizatio*n involved the comparison of self-reported SRL strategy use in the journaling and interviews. *Multiple validities legitimation* was considered: the MAE survey has been validated and found reliable for the engineering population[36,38,136] and additional validity testing, such as finding Cronbach's alpha[186] and running an exploratory factor analysis (EFA)[160] was completed. *Political legitimation* was considered during writing, as to make the research relevant, applicable, and tangible to practitioners, who are the most relevant audience. Additionally, a strong theoretical background and frameworks were utilized to ensure engineering education researchers will be able to interpret and utilize the results. The mixing of this research strengthens the studies in this context, as some researchers will be familiar with one type of research (e.g. qualitative) but not the other. By mixing, it allows the reader to utilize a familiar methodology to shine a light on a new type of methodology.

On the qualitative side, the *Quality Framework*[104,106] was considered through the design, collection, and analysis. Building rapport in a qualitative study helped support *procedural, communicative, ethical, and process validity*[104,106104]. Two interviewers were used for every interview and at least one interviewer/researcher was the same for both interviews. The interviewer/researcher became an advocate for each participant's experience through building trust during multiple points of contact. Additionally, *process validity* was included due to the building of trust throughout the research process.

This research utilized several aspects of rapport and trust building from Maxwell[209]: reflexivity and sustained contact. One key piece of the case study development was reflexivity: the continuous development and change in a relationship between interviewer/researcher and the participant. For this study, the researcher relationship with the case study participants began forming while hosting a workshop on SRL in their course, and continued to grow and change. Building trust is important for an interviewer, and can be one of the limitations of interviewing[210]. During interviews, the interviewers ensured the students were comfortable and honest. For example, key questions were repeated in different ways, and when a participant opened up about use of SRL strategies, they were asked to be honest about their actual use.

Sustained contact was used to encourage a positive development in the relationship between the interviewer/researcher and case study participants including multiple contact points, triangulation, and multiple interviews. For example, the SRL workshop was designed to help the students fluently discuss their SRL strategy use and to begin the rapport building between the researcher and participants. This fluency assisted with the data collection and analysis portion of the research. Additionally, the participants were more familiar and comfortable with the researcher, as they recognized the face, name, and position of the researcher on campus. Case study participants were also interviewed two times and contacted for member checking of the results and writing; having multiple points of contact is important for developing and maintaining a relationship[211,212]. Participants were thus provided multiple chances to get more comfortable, disclose information, or withdraw something they said. These opportunities provided a fuller, rich/thick description of the case study, supporting *communicative validity.* This validity was also supported by triangulation[197,213–215] from multiple sources of data (surveys, interviews, and journals). Specifically, MSE course grades earned by the participants were used to triangulate MSE journal data which detailed goal or earned grades and SRL strategies.

Semi-structured interview protocols were used to increase flexibility. If a student appeared hesitant, students were asked if they are comfortable or if they would like to change the topic. Other researchers were utilized to review data and interpretation to ensure the participant's full experience was included, supporting *ethical validity.*

Participants were informed about the purpose of the interview and consulted through the data analysis and write-up process, which led to a more open conversation[216]. Rather than just supplying information letters, as required by IRB, interviews began with a short discussion about how important the student experience is to the understanding of FTP and SRL and how this could be used later. Participants were more willing to share their knowledge, experience, and information after they understood that the information would be put to good use to support students in their situation in the future. Additionally, member checking was used to support *communicative* and *ethical validity*, because it ensured co-constructing interpretations and results with the participants. Yin[201] recommends sharing pieces or all of the draft or final report with the participants to support *construct validity*, and a draft of the report was shared with the individual participants which assisted in clarifying some things, finding errors, identifying misquotes, updating responses, etc., additionally upholding *communicative, procedural,* and *ethical validity.*

Overall, quality for this study was heavily considered. First, being aware of researcher bias was important to know in regards to quality, and the researcher bracketed[217] before beginning data collection and added to this list of biases as the research continued. The limitations section in Chapter 7 includes a description of possible bias. Additionally, clear and consistent tracking of research design, methods, data collection, and data analysis is vital to the trustworthiness of a study[197,213]. Throughout these studies, extensive documentation was recorded and kept in such a way that another researcher would be able to access the documents and understand the research process. This research was written concurrently with the data collection and analysis phases, rather than waiting until the end of the data analysis phase. For example, codebooks were created or updated throughout each study, so that definitions and representative quotes could be clear for all themes within each theory. Additionally, all data and supplemental documents were saved in a single folder and clearly labeled.

6.3 Results

Three case studies, Barb, Cody, and Greg, and a cross case analysis are described in this section. The results are written primarily in third-person present tense. Here, the present tense is used to authentically represent the participants' descriptions of their experiences, FTP, and SRL strategy use at a particular point in time (spring semester). Anything written in past tense occurred before interviews with the students. Themes in the SRLIS or FTP cone framework are shown in italics, and SRL strategies commonly used by a case study participant are underlined for reference within the SRL sections. Additionally, goals which were written or described verbatim are shown in quotes within the text.

6.3.1 Case Study 1: Barb

Barb is an Asian, second-year engineering student majoring in Biomedical Engineering (BME). She picked a degree in engineering because she had an interest in math and science. She selected BME as an engineering discipline as it is “medical-related,” and she has a goal to work in medicine. Barb, however, does not plan on being in an engineering-related profession after graduation and considers becoming a BME a backup career. In the future, Barb desires a doctorate because she wants to feel a sense of accomplishment, and her role models, her parents, both have doctorates.

Barb’s future goals are primarily career-focused and she stated that as a college student, her career goals are on her mind. Barb feels like she has a lot of possibilities for what she can be in the future: "I mean I feel like I have a lot of options open to me. I guess, just a lot of things to be honest." She has decided on her future goals through a combination of experience and outside expectations. Barb conceives her future goals through past experiences and said, "I guess, some through shadowing, I'd say. Seeing other people and then also maybe stuff from media in that sense.” While she has a lot of “options,” Barb plays the cello and guitar but knows she does not want to pursue it as a career; she is happy enjoying it as a hobby.

Personally, she would like to see herself married with children "eventually" and spend time traveling. She would like to travel primarily for fun, but she would not mind traveling for business, especially to Europe. She would ideally like to live in California because of the weather, mountains, and beach. Barb also wants to have dog and walk the entirety of a US Trail.

Barb's Description of Success and Failure

Barb defines success as “being happy with what you're doing every day” and believes success in her studying is when she sees the “results” of her study habits. By results, Barb is referring to meeting her goals of obtaining particular grades. Alternatively, Barb considers failure as not meeting her own expectations or what she can achieve. She said, “[Failure is] personally knowing what I can attain and coming short of that. Really in just anything I do I guess." In terms of studying, Barb adapts her skills when they are not working and if she has not reached her grade goals.

Changes in Barb's Future Possible Career and Impact of Present tasks on Future Goals

When entering the university, Barb thought she wanted to attend medical school. She changed her future goals, specifically her distal future career goal (DFCG) which in turn updated her proximal sub-goals (PSGs), based on an internship experience. Her ideal future career goal and DFG up through the summer before her second-year at the university was to become an anesthesiologist, but after her summer internship experience shadowing a doctor, her ideal future goal became an avoided future goal. Because of this avoided future goal, Barb shifted into a Waffle Cone FTP type.

After this shift in goals following her summer internship, Barb remained interested in the medical field due to her interests of math, science, and medicine. In the fall semester, Barb's FTP type based on her MAE survey scores was a Waffle Cone FTP type, with medium F score (4.5 out of 7), high PI (6 out of 7), and low FoP score (3.5 out of 7), which matches her qualitative FTP journey. Though she did not mention a "realistic" contrasting future goal, which is common trait for a Waffle Cone FTP, she has a "realistic" avoided goal of becoming an anesthesiologist which she had been working towards and a new, open, "ideal" path, which she was working to clarify.

After a winter internship, Barb selected a new medical career path as a pharmacist. She spoke about her experience at her winter internship and said, "For the pharmacy-related stuff I actually shadowed a pharmacist of the job I was describing. Where he will work for the hospital most of the time, but then also teach a class, like clinical style. So, shadowed him for about a week." This experience helped Barb define her current DFCG, becoming a pharmacist.

Through this winter internship, Barb updated her future goals, changing her path and her FTP classification. Her spring MAE scores, when reflecting on an upper-level BME course, were low for F (3.75 out of 7), medium for PI (4 out of 7), and low for FoP (3 out of 7), again indicating Waffle Cone FTP type. However, in the spring Barb has a Sugar Cone FTP with well-defined future goals, a matching ideal and realistic future career goal, a clear view of the impact of her future goals on her present tasks, and a high endogenous PI for courses and skills she feels are relevant to her future goals. As she is planning to become a pharmacist, the course she used as her reflective task may have affected her medium PI score, which appears to be high through her interview responses. While a high grade in all of her courses will be important for reaching her goals, Barb may not consider the material in this particular BME course relevant to her DFCG. The low number of FoP items remaining in the construct and the reflective course selection could have skewed her FoP score.

Barb's Distal Future Goals

Barb's distal future goal (DFG) is to "be happy," and she said this goal was the most important and influential in setting all her other goals. Barb also believes that becoming a pharmacist, her DFCG, is significant and her second most important goal. She feels being a pharmacist will help her enjoy what she is doing day-to-day and so will contribute significantly to her happiness. Within ten years, Barb can see herself practicing as a pharmacist, married, and with one child. Her idea of being a practicing pharmacist includes a dual role working in a pharmacy and then teaching one or two days a week. In particular, Barb is currently pursuing a position in a hospital that allows her to work for one day out of five or six at the university where she can teach pharmacy coursework. She describes this job as a "clinical teaching position." Barbs believes she truly can be a pharmacist and is striving for that path. All of her sub-goals are set to reach her DFCG, and she currently has a matching ideal and realistic future.

Figure 6.2: Barb wrote her DFG (blue), DFCG (red), and Short-term DFCG (purple) on cards during the second interview. She has a clear path of working as a pharmacist after attending pharmacy school, to reach her DFG.

Based on her DFCG, Barb has set up a path of contingent and non-contingent proximal sub-goals. Barb has a mostly contingent path leading from her present to her DFG. First, Barb must earn a strong PCAT score and graduate with a strong GPA to attend pharmacy school. Then, Barb needs to complete pharmacy school and earn her doctorate of pharmacy to obtain a job in residency. Barb's DFG, DFCG at 10 years as a pharmacist, and DFCG at 5 years of attending pharmacy school are shown in Figure 6.2. Her future pharmacist job directly relies on her success in residency. Barb also believes that to obtain her DFG, she must have a job she loves. She believes the dual-role pharmacy position will be a job she loves, which will help her meet her DFG. One goal that Barb does not consider necessary for obtaining her future goals is completing internships, but she does believe she needs some sort of related experience to obtain her proximal sub-goal of attending pharmacy school.

Barb's Perceptions of the Impact of her Future Goals on her Present Actions

Barb feels like reaching each goal on her timeline contributes to her DFG of being happy. She has set goals in her path that are motivated by her DFCG, which in turn allows her to meet her DFG. For example, her current goal of obtaining a 4.0 GPA for the semester will support her in obtaining happiness by allowing her to finish the semester successfully. Additionally, finishing the semester will lead to happiness for Barb as she is excited for her summer plans. She has set each sub-goal leading to the next goal, all to reach her DFG.

Barb has set herself up for several opportunities which will help her build skills and experience related to her future goals. Barb is involved in undergraduate research, which will help her clarify her future goals, and plans to attend a national conference and present. She is working regularly with her group, which is supportive of her development in her field and will help her reach her future goals. She is using this experience to build her networking skills as well, which she believes will be valuable later. Additionally, this experience will teach Barb about research.

Barb's short-term future goals also impact her present actions. For example, Barb has "successfully getting through the semester" as a goal and has set a goal of "making a 4.0" as the measure of success. To meet her grade goal, Barb is setting time aside for each course to study. She will ensure she understands the material by making sure she remembers it and can use it later. Relatedly, when Barb begins her internship this summer, she will seek out the help of colleagues to figure out what she does not know, especially to figure out which project she should start on once she arrives; she will have the pick of multiple projects. Both of these examples show Barb using SRL strategies in the present to obtain her future goals.

Relatedly, Barb sees the current value in experiences she is having that she will use in the future. Barb credits her education, including the work ethic and coursework she is learning, as being useful for her future and her career: "[My education] definitely provides a foundation for me to then use those skills to build on it and use them, but then also gain new ones." Barb provides tours through the BME department, though she did not sign up for this experience with intent to impact her DFCG; she now sees this experience as a way to develop valuable skills toward her future goals. For example, she is building skills as a better teacher by explaining and leading tours, which will support her ability to teach in a dual-role pharmacy position.

In particular, Barb's future goals have an impact on what experiences she is selecting in the present. For the next summer, Barb has accepted a position working with drug abuse research with the government during the first half, and she will be studying abroad and conducting drug delivery research during the second half. She believes these positions will support her future pharmacist-related goals as they both deal with medicine and drug-related research. Barb pursued these experiences as she was thinking about ways that she could gain experience in the present that would help her with her future goals. The effect her future has on her present then creates a feedback loop because Barb will gain skills and experience related to her future, which will then in turn update her goals.

Additionally, Barb has consistently sought to gain relevant experience as an important part of meeting her DFCG and DFG. Through those experiences, she has adapted to her DFCG, specifically moving from anesthesiologist to pharmacist.

Barb's Openness to Change

Related to Barb's feedback loop between the future and present, Barb said she would change her goals if she finds, through some experience, that she does not think she would enjoy being a pharmacist. She sees the value in having experiences now, such as undergraduate research, that will help her decide and is setting herself up in the present for experiences to help her clarify her future career goals. Additionally, Barb realizes that even once she is in pharmacy school, she may realize she does not wish to pursue the pharmacist position, and she hopes it will not be too late at that point to change careers. She realizes that she will need to decide later if she actually wants to become a pharmacist or end up working in a BME position, her backup, because she will have more experiences that will show her if she actually enjoys pharmacy education and life as a pharmacist. However, Barb is persistent and believes she wants to do pharmacy; she said, "To be honest, I'm pretty set on this. I guess if I just find, maybe, a passion, and maybe if I do some sort of design of a project or something and really like it."

Barb's Perceived Instrumentality of Present Tasks

Barb feels that there is a piece of every class she's taking that is relevant to her future. Specifically, she said it depends on the classes; for example, her BME classes all have some pieces of relevant material. She also thinks her drug delivery class is very relevant to her future because she plans on doing research with drugs and becoming a pharmacist.

Even though Barb plans on never being in an engineering-related field, she still plans on using the skills that she is learning in her future goals. Thus, she is intent on leveraging her classes during her time at the university. She plans to use engineering-related material for at least six years, as her BME degree will support her through pharmacy school, residency, specialization, and then finally becoming a pharmacist in the dual role.

When Barb finds the material in a course relevant, such as BME department courses or science and engineering classes, she sees getting to know the professor as beneficial to her future. Barb believes utilizing her BME professors as a resource is beneficial in the present and for her future. In the present, Barb feels professors are helpful for learning information and during office hours. In the future, Barb believes building on current relationships with her BME professors will ensure they are more available if she ever needs assistance in her field and more helpful in obtaining possible BME-related experiences. She saw this first hand when she obtained her upcoming summer study abroad experience after building a professional relationship by networking with one of her BME professors.

Barb has a high endogenous PI for experiences which she feels will build skills or contain relevant content to her future goals. For example, Barb believes the connections she will make and professional experiences she will have during her summer internships are extremely valuable. She believes she will learn important skills, such as researching, and more about the profession.

Barb has a high endogenous PI for courses related to her career and exogenous PI for all of her courses. In particular, Barb feels any content in courses related to the PCAT, the exam for pharmacy school entrance, will be valuable. Barb believes her chemistry and biology courses relate to her pharmacy career path and she feels she needs to study for these courses to understand them and use the material later. Barb realizes the content in her BME courses is often relevant to her career path of choice, such as courses related to drug delivery, anatomy, chemistry, bio materials, and others; she thinks some of BME major-specific material is irrelevant. However, she feels every course she takes has some aspect that is relevant, for example her outdoor leadership course teaches her about leadership which will be important in her dual-role position as she will be teaching. Additionally, Barb has an exogenous PI for all of her courses because of her grade goals, specifically earning a 4.0 each semester. She is additionally motivated by her need for a high GPA for admittance into pharmacy school which supports her exogenous PI.

In her current major and extracurricular activities, Barb believes she is learning skills relevant to her future career. She feels leadership, work ethic, personal, organizational, time management, and communication skills will support her career goals. Additionally, by being involved on campus and participating in past summer camps, Barb feels she gained skills in meeting and relating to new people; she feels these are important skills for her DFCG.

Barb's Use of General SRL Strategies

Barb believes a study skill is being "able to comprehend all of the material and be able to explain it to another person." She believes she has learned something when she can teach it to others. Barb uses her study skills for "whatever goal I'm working at at the moment" such as completing a homework assignment or studying for an exam. Barb is motivated to study by grades and studies more, and in a more self-regulated way, when the material relates to her future goals. While Barb does not plan on ever having an engineering-related position, she uses engineering study skills in hopes to learn how to do new things and be able to apply what she has learned later for new hobbies and ideas in the future.

Overall, Barb reported that she uses the same strategies for engineering and non-engineering courses; however, she identified *rehearsing and memorizing* as the strategy that she primarily uses when studying for BME courses. In particular, Barb uses notecards for biology, biological materials, and other material/content-heavy courses in BME. Additionally, Barb only elucidated using *reviewing records* strategies for her engineering-related courses, where she will review a study guide or an old exam provided by the professor. Generally, Barb uses three main study strategies: <u>compartmentalization</u> of material, <u>listening rather than taking notes during lecture</u>, and <u>studying in a group</u>. Moreover, all of Barb's study habits cover all SRLIS themes, except *self-monitoring and keeping records* and *using self-consequences*.

One main strategy Barb uses is to "<u>compartmentalize stuff</u>," meaning she learns and remembers it "chronologically," a general *rehearsing and memorizing,* and possibly *organizing and transforming,* strategy. Barb described herself as remembering things in chronological order; for example, she may remember information from a picture during a certain study session or "that it was before this certain point." This is a type of *organizing and transforming* as Barb is associating material in an ordered way. If she is struggling with a topic, she will try to remember what came before it, and that will help it “click.”

The second key strategy that Barb uses to regulate her learning is <u>listening in lectures</u> rather than taking notes, which uses *structuring the learning environment* and *self-evaluating*. Her main reason for using this strategy is efficiency, and Barb said “If I try and note take while listening, I normally will only get half of each, and that doesn't help anyone.” She knows this works for her from past experience, and she explained “I know that when I was younger, say like my parents were telling me something and I was writing it down, I would normally ... If it was one sentence I would have to have them repeat it like three times for me to get it all down. I guess just realizing that when I'm notetaking I only get part of it.” This shows she updated her strategies based on self-evaluation.

The final main strategy that Barb uses to study is learning in a <u>study group</u>, which for Barb uses aspects of *structuring the learning environment*, *self-evaluating*, and *seeking social assistance*. Barb studies by meeting with a group to "reinforce what [she knows] and also help the other person." Filling in the gaps she does not know is *seeking social assistance.* Barb’s use of study groups for learning is also a form of *self-evaluation,* as she is using a study group to assess her learning and knowledge. She ensures she can explain material to the group. Barb also uses the study group as social motivation to learn, one way in which Barb *structures her learning environment*. Finally, Barb leaves the study group as soon as she finds it ineffective (*self-evaluating*).

While Barb uses her peers as *social assistance* in a study group, she also seeks it from her professors. Barb also uses *seeking information* strategies, which she prefers to use but does not find as beneficial as seeking social assistance. While she would rather use Khan Academy or other online resources, she will use tutoring programs to support in her classes. Barb is more likely to *seek social assistance* from a professor for her engineering-related courses, which she defines as “science classes, science engineering classes.” She uses her professors in her BME-related courses to get to know them, support her in her learning, and also in case they may be an asset later. Barb believes it is important to get to know professors in her department so that she receives help now in class or in the future when she is trying to obtain her future sub-goals. In relation to using her professors as a resource, Barb said, “I guess since I'm a [biomedical] engineer, it's helpful to know professors within the department in case I ever need any help or anything. Also I think it helps to know them when you're in their class... I guess more attention in that sense because they know who I am.” She believes that if her professors know who she is will help her when she attends office hours or goes to seek out the assistance from that professor. Barb explained that she was able to obtain her upcoming summer study abroad experience due to her relationship with a professor which she had built through *seeking social assistance*. Outside of class, but related her to BME major, Barb is preparing for her study abroad, by using *seeking social assistance* strategies such as meeting biweekly with her research team.

Barb disclosed that she limitedly uses *planning and goal-setting* strategies. She would like to start studying earlier but, up to this point, she only starts studying for exams at most two days in advance. Specifically, Barb figures out what she needs to learn for her exam and then will incorporate studying into her schedule with enough time to "master that stuff." When studying for an exam, she primarily uses *planning and goal-setting* and *structuring the learning environment* (plays music) strategies. She sets goals by "Definitely seeing what I want in the end goal and I guess making attainable, making it in chunks I guess of how I can reach that." In particular, Barb sets goals "when something's important enough," so if she finds it valuable, she is more apt to set a concrete goal.

Barb uses *self-evaluating* by updating her strategies as she needs them. She tries out new study skills and continues to use them if they have worked in the past; for example, the "compartmentalization" technique has worked for her so she continues to use it. Barb updates her SRL strategies if they are not working as indicated by not attaining her grade goals. Barb realizes she will have to update her study skills, especially in junior year as she has heard it is particularly difficult in BME. She uses her grades to motivate her and to self-evaluate if she has self-regulated sufficiently.

Barb's Use of SRL in Major-Required MSE Course

In her MSE course, Barb studied using some of her core study habits, such as studying in a group and *reviewing records* for her engineering-related material. However, she *self-evaluated* along the way and did not change her study habits until after Exam 3, when she realized she was not going to reach her grade goal. This motivation forced her to further *self-evaluate* and finally adjust her self-regulation.

For Exam 1, Barb honestly stated, "I set a couple goals but I do not think I set enough." Primarily, Barb used *reviewing records* and *seeking social assistance*. She reviewed records in the form of completing multiple practice exams, reviewing old exams, looking over notes, and reviewing worksheets. Barb also used her typical strategy of studying in a group; the night before Exam 1, she studied with "a group of five." In this study group, they worked together to create flashcards to learn vocabulary and utilized the whiteboard to work problems (*rehearsing and memorizing*). Barb wished she had set more goals and started reviewing earlier, showing her *self-evaluation* of the effectiveness of her SRL strategy use.

For Exam 2, Barb utilized *seeking social assistance* by attending office hours and using a study group. She also *structured her learning environment* (study room with white boards for study group) and *reviewed records* (slides). By starting with a particular unit she struggled in, Barb *self-evaluated* and utilized *planning and goal-setting* during her exam prep. Barb also used *structuring the learning environment* strategies by purposefully paying attention in class. Finally, Barb compiled old exams and reworked them (*rehearsing and memorizing*). During this exam period, Barb failed to use *reviewing* *records* strategies that she deems essential, as she failed to keep up with required reading She also lacked *planning and goal-setting* by starting late in her studying.

Finally, for her third exam, Barb again failed to keep up with the readings (*reviewing records*), but she utilized several of her standard strategies: *seeking social assistance*, *structuring the learning environment*, and *rehearsing and memorizing*. However, for Exam 3, Barb was able to start studying earlier (*planning and goal-setting*) after *self-evaluating* and changing up SRL strategy use to meet her grade goal for the course. Barb relatedly said, "I kept up with the class, the modules, and started studying earlier. This combination allowed me to get a good grade on the exam."

The Creation of Barb's Path of Distal Future Goal, Distal Future Career Goal, and Proximal Sub-goals

During her second interview, Barb discussed her goals from her first interview. Initially, she read the cards and when prompted, created a timeline of her goals, as seen in Figure 6.3. Barb has a set of clear, well-defined goals that reach over ten years into the future.

Barb altered several goals during her path creation. Specifically, “finish this semester” was combined during path creation with “successfully getting through the semester” and “[earn] a 4.0 this semester.” All her goals lead up to her goal of becoming a pharmacist (DFCG), and her paths maps from succeeding during the spring semester, completing experiences related to her DFCG, and graduating.

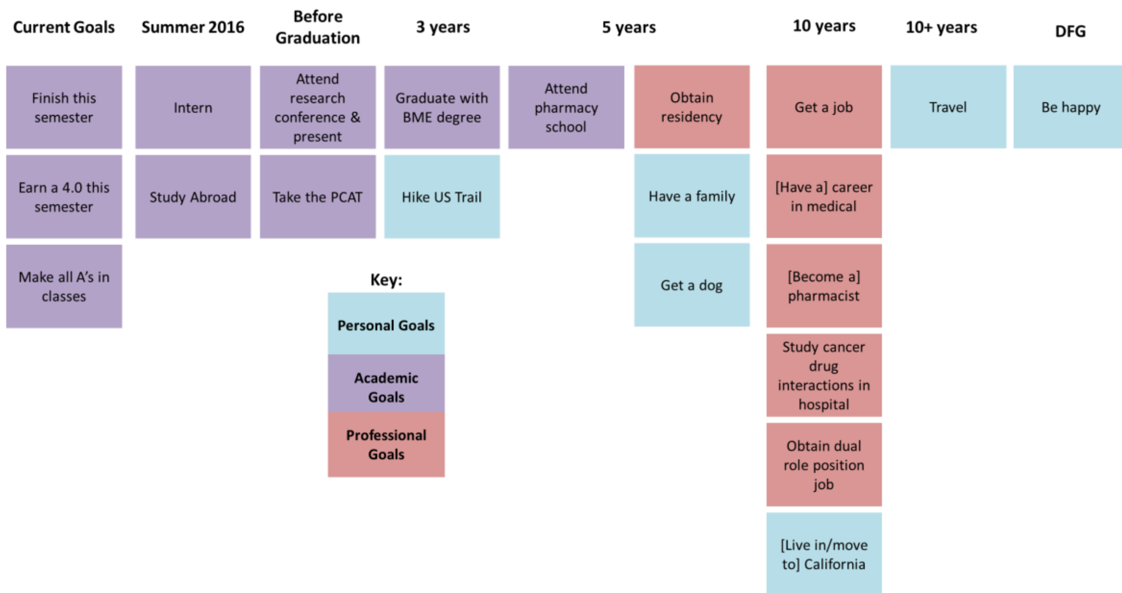


Figure 6.3: A color-coded version of Barb's path of goals from Interview 2.

Strategies for completing the proximal sub-goals in Barb's path

Barb uses SRL strategies to obtain many of her goals listed in Figure 6.3 which depicts her goals and some of the strategies she is using or plans to use to obtain each of her goals. A list of strategies she is using to obtain each of her goals in Figure 6.3 are listed in Table 6.1. For graduating on time in May 2018, Barb plans each semester before her registration time (*planning and goal-setting*). To hike the US Trail, Barb uses *planning and goal-setting*, *record keeping*, *seeking social assistance*, and *seeking information*. To attend pharmacy school, Barb plans to utilize *seeking social assistance* strategies by learning from clinicians and pharmacists during her internship experiences.

Barb believes meeting her PSGs will support her procurement of further future sub-goals. She thinks hiking a specific US Trail will support her application and entrance

Table 6.1: Barb's list of goals from her path, including the type of goal, or grouping, and the strategies used to achieve each goal.

Goal	Strategies Used or Notes
Get a job	None listed
Get a dog	None listed
[Have a] family	• Maybe meet [partner] in pharmacy school
[Have a] career in medical	None listed
[Get the] dual role (teaching & pharmacy) job	None listed
[Become a] pharmacist	• Do well at sub-goals
[Attend] pharmacy school (including Doctorate)	• Research prerequisites • Take pharmacy-related classes on top of BME classes • Be involved because pharmacy school wants an "all-around" person
[Obtain] residency	• Do well in pharmacy school
Finish this semester	Note: This goal was combined during path creation with "Successfully getting through the semester" and "[Earn] a 4.0 this semester"
Graduate with BME degree	• Take one semester at a time • Registering • Happy to motivate
[Take the] PCAT	• [Complete relevant] coursework • Review • [Practice and learn] test-taking skills • Use PCAT books [to prepare]
Travel	• Profession allows • Know how to budget
Study cancer drug interactions through hospital	• Doing research now • Shadowing (solidify she knows what she wants to do)
Study abroad next summer	• [Conduct] BME research • [Go to] Thailand • [Complete] paperwork • Learn culture • [Attend] weekly meeting [to prepare for study abroad] • Plan for weekends, flights, etc.
[Live in/move to] California	None listed
[Attend] BMES [undergraduate research] conference and present	• Set smaller goals • [Attend] weekly meetings
Hike [US trail]	• Prepare • Map out plan • Pick group • [Obtain appropriate] fitness level
[Have a] summer internship	• Already accepted • Select project 1st 2 [weeks] • [Figure out] resources to be helpful (other doctors and other researchers)

Make A’s in all classes	• Understanding material • Remember • Use later on
[Earn a] 4.0 this semester	• Plan time to study

into pharmacy school because it's extracurricular and "...having stuff that's not just school-related...being passionate about other stuff” is important for admittance. Additionally, Barb considers obtaining a good score on the PCAT as a contingent goal in her path to pharmacy school. Another contingent goal in Barb’s path is doing well in pharmacy school to obtain a good residency. Barb’s contingent goals along her path activate perceptions of instrumentality, endogenous and exogenous, as she believes she must meet these goals to obtain her DFCG. Thus, Barb self-regulates to meet the PSGs in her path.

Barb feels grades are extremely important and help her reach her present and future goals. Her current goals of “finish this semester,” “[earn a] 4.0 this semester,” and “make A’s in classes” are success- and grade-oriented, and Barb utilizes her SRL study behaviors to reach these short-term goals. In particular, to assist in earning a 4.0 in the spring semester, Barb uses *planning and goal-setting* strategies by planning time to study. She plans to use 10 minute increments to review, and also plans to study for her exams/finals during the last two weeks of school using the 10-minute review method.

Barb has goals for her major, her courses, and for specific studying sessions. She is motivated to earn a 4.0 this semester, which she feels is equivalent to the goal of earning an A in each of her courses. She believes that having a goal of earning an A in each class will help her to meet her goal of a 4.0 by motivating her in each of her classes. While she is taking a heavy load of 19 hours, she feels it is important to her career as a pharmacist to get into pharmacy school, and she will need a 4.0 to achieve the GPA she wants to get in. To achieve that goal for the spring semester, she is *self-evaluating* and tracking her grades. Relatedly, and what she considers course goals, Barb wants to earn A's in each of her registered classes, as she feels she needs those grades to get into pharmacy school. She is primarily allotting time to ensure she can earn these grades (*planning and goal-setting*, *structuring the learning environment*). Additionally, Barb has a goal of being accepted to an important conference for the fall in her field, which she would attend through her research program at the university. Barb has set, with her research group, a path of goals to reach this overarching conference goal. She meets weekly with her team and is working on a paper to submit (*setting goals and planning*). Finally, Barb sets goals when she studies primarily by *planning and goal-setting* and *self-evaluating*. She figures out what she needs to know and how much she will need to study. She then sets goals for what she feels she should accomplish that day. For example, for her biology course, Barb will study the question guides distributed by her professor for each lecture, and she may set a goal of study a certain portion of those guides per day. Overall, Barb feels it is important to set goals for your coursework and major to stay motivated. For studying, Barb sets goals to know that she has done enough and knows the material. However, "to make you grow more" is the reason she feels it is important to set goals for your career; she feels setting career goals sets her up to obtain "higher things."

The value or importance Barb places on a goal has a strong connection to her self-regulatory habits. When Barb feels material is medical-related or relevant to the

PCAT/pharmacy school, she studies it and makes sure she can explain it (*self-evaluating*). She uses strategies as a skill she needs in the future and believes these self-regulatory strategies will help her be more efficient. She said, "There's always work that's going to have to be done, and so the more efficient it can be, the better you'll be at your job." Unfortunately, Barb does not set goals for things she feels are small or unimportant, such as homework or other small school stuff, thereby limiting her *planning and goal-setting* strategy use in the present.

Barb's Connectedness for Sub-goals in Path

Barb rated the importance of her goals in her path to her DFG, "be happy," and her scores increase from 5 up to a score of 10 as the goals approach her DFG in the future. Many of her goals were rated 10, as seen in Table 6.2, meaning her happiness is contingent upon her reaching these goals. For example, Barb believes she must achieve a career in the medical field to be happy. However, Barb has other contingent paths within her overall set of goals, as she must graduate to attend pharmacy school. Barb has specified a goal of graduating with a BME degree, rather than simply graduating, as she believes this degree will support her future goals. While she rates graduating with this particular degree an 8, graduation is a goal she must obtain to attend pharmacy school; thus, graduation is a contingent goal in Barb's path from the present to her DFCG and then DFG. Similarly, none of Barb's goals are rated below a 5, meaning she values all of her PSGs in achieving her "be happy" goal. Barb's closest goal to the present that is rated a 10 is her goal of "finish this semester." Barb realizes that continuing her education at this point is important toward reaching her DFCG and will support her goal of graduating, more than a specific major will assist. Besides her goal to finish the semester, Barb's further future goals score higher in their connection to Barb reaching her DFG than closer proximal sub-goals.

Table 6.2: The Connectedness score placed on the goal in the left column in reaching the goal in the top row during Barb's path creation in Interview 2.

Goal	Connectedness Score
Get a job	10
Get a dog	10
[Have a] family	10
[Have a] career in medical	10
[Get the] dual role (teaching & pharmacy) job	10
[Become a] pharmacist	10
[Attend] pharmacy school (including Doctorate)	10
[Obtain] residency	10
Finish this semester	10
Graduate with BME degree	8
[Take the] PCAT	8
Travel	7
Study cancer drug interactions through hospital	7
Study abroad	7
[Live in/move to] California	7
[Attend] BMES [undergraduate research] conference	7
Hike [US trail]	6
[Have a] summer internship	6
Make A's in all classes	5
[Earn a] 4.0 this semester	5

FTP Characteristics and Connections to SRL Elicited from Barb's Path

Barb's DFG guides her DFCG, and she said, "I guess the main one is working towards what I want to do in life. Again, smaller stuff like hanging out with friends, doing outdoors stuff." Barb's goals are well-defined, especially leading from current goals through getting her "dream job of the dual role." Barb is only considering one DFCG, the dual-role pharmacy position, and all other jobs she has considered are in medicine. While

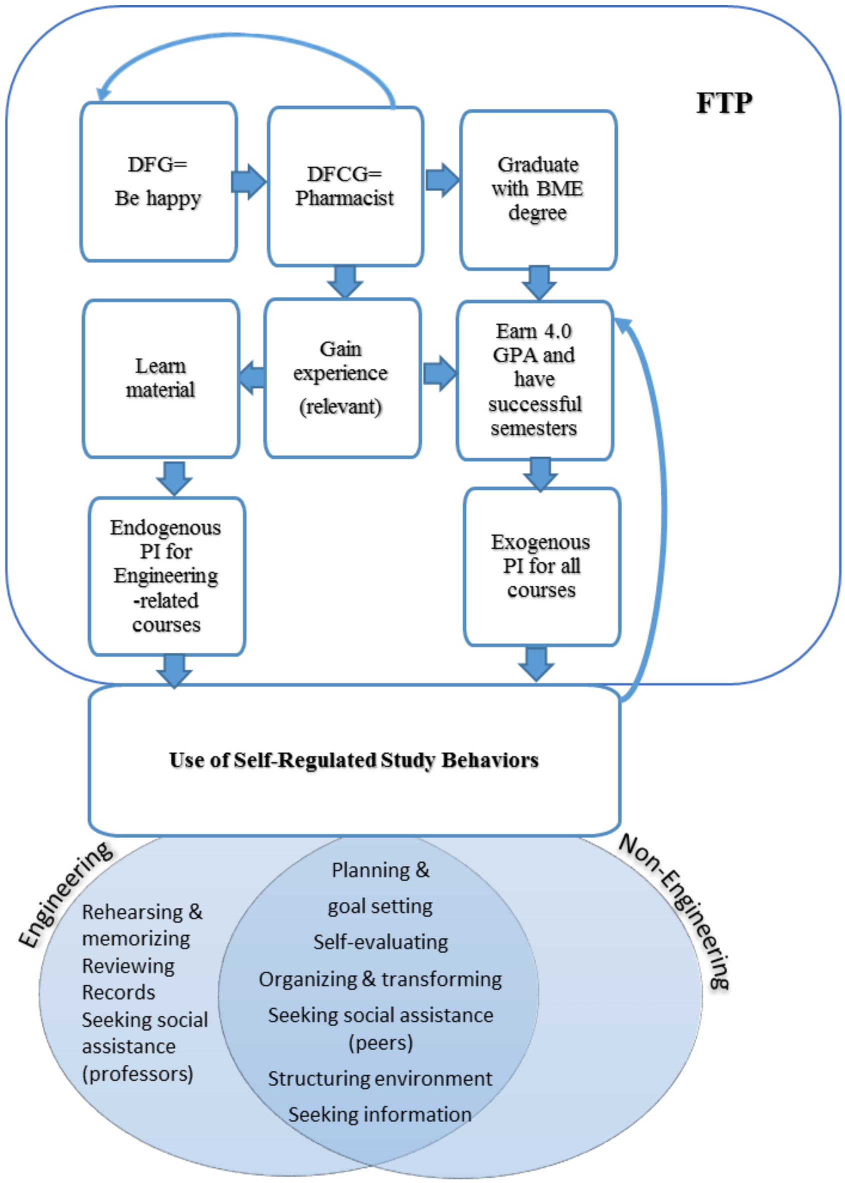


Figure 6.4: A model of the connection between Barb's FTP and her use of SRL strategies in the present.

Barb does not consider interning a contingent goal for reaching her DFCG, she does believe is it essential to obtain some sort of related experience, making gaining experience a contingent goal. Her SRL strategies get less and less specific, as do her goals, as she reaches her DFG of being happy. However, her SRL strategy use and path of goals are more specific leading up to pharmacy school, and even into residency. She can see into ten years but not too far after. If Barb decided on another path, her path wouldn't diverge until after graduation. However, she is "90%" sure she wants to do pharmacy. Barb's openness to change her DFCG and path of future goals if she is not reaching her DFG is shown by the feedback loop between her DFCG and DFG in Figure 6.4.

Furthermore, Figure 6.4 shows the connection between Barb's FTP and her SRL strategy use in the present. Her DFG motivated the creation of her DFCG, which in turn assisted in the creation of a set of PSGs. Barb's DFCG motivates her to graduate with a BME degree and to gain relevant experience in her field. Both of these sub-goals push Barb to set achievement goal grades. Her grade goals perpetuate exogenous PI in all of her courses, activating SRL to achieve those goals. Additionally, Barb's goal of gaining experience relevant to her DFCG activates endogenous PI for her engineering- and PCAT-related courses. In turn, Barb utilizes self-regulated study behaviors to learn the material in her courses. As shown in Figure 6.4 and discussed previously, Barb utilizes a set of SRL strategies for engineering and a common set of SRL strategies for all courses. Finally, Barb updates her SRL strategies based on the graded work she receives in her courses, as revealed when she said, “I know [my study skills] have to be good to be able to get the grades that I need. So, making sure that whatever I'm doing is working.” This feedback loop between Barb’s grade goals and her SRL strategy use is depicted in Figure 6.4.

6.3.2 Case Study 2: Cody

Cody is a Caucasian, male, second-year mechanical engineering (ME) undergraduate student. He speaks highly of engineers and is proud to pursue an engineering degree. He feels he is suited to engineering due to his “fact finder” personality. Cody hopes to get several things from his engineering degree: 1) money, 2) good grades, and 3) a greater understanding.

Cody came to his university to pursue becoming a park ranger. He quickly realized that it would be hard to support a family and find a position. He considered Environmental Engineering (ENE), but the major did not meet his expectations. He was hoping ENE would focus on clean environment techniques, but most of his coursework was related to water treatment. Then, Cody decided on ME as a major because he believed it to be broad enough for any engineering-related position he may pursue. Now that he has learned more about engineering, he realizes that that an engineering major prepares you for more than just building things. He believes employers will hire engineers because they learn to think critically and can break things down. Thus, he believes engineering is the best thing to pursue for the future he desires.

Changes in Cody’s Future Possible Career

In the fall semester, Cody was still deciding between two career paths: Aerospace Engineering (AE) and Renewable Energy (RE). He was considering a broad range of future possible careers in these paths, and, therefore, his qualitative and quantitative characteristics matched a Cake Cone FTP type. Cody clustered as a Cake Cone FTP based on his scores on the MAE survey in the MSE course in the fall, with composite scores medium F (3.75 out of 7), high PI (7 out of 7), and low FoP (1.5 out of 7). In the following spring semester, Cody described his intention to follow RE as his career path by saying "I've always been a huge fan of space and dreamt about space and working in aerospace industry, but renewables seems like something I'm more passionate about." When asked about his ideal future, he jokingly said that he would "be making nuclear fuel for rockets to go up into space" which he considers the renewables field but is a hybrid role combining airplanes and space with renewables. This particular position is a fantasy future [218] and not something that Cody has seriously pursued or considered.

While his ideal and realistic paths match his renewables career dreams, he has yet to give up his interest and passion for planes. Since he does not consider combining AE and RE as a serious option and is currently pursuing RE-related goals, AE is Cody’s backup career path. After interviewing for internships in the fall, Cody decided on an RE internship in nuclear power with an energy company. He also had an opportunity for an AE internship at an AE company; however, he has narrowed his focus into the RE field. If he ever decides to go the AE route, Cody will pursue possibilities related to his previous experience on a research project with a national AE organization. While Cody is honing in on RE as his career path, he has lingering AE interests such as repairing aircraft, liaison engineering, design, and working on spaceships or turbine engines. He disclosed that while he is working on nuclear energy (NE) this summer, he plans to apply to AE positions in the future to be sure to gain experience in both, if only to open his career options later. He realizes that, depending on his internship experiences, his path may shift in a different direction.

Cody's Distal Future Goals

In the following spring semester, Cody has clarified his career path to a set of well-defined goals. Cody has four distal future goals (DFGs), which he refers to as his "end game goals": 1) be happy, 2) make a difference, 3) live sustainably, and 4) be successful. When Cody describes his goal of "be successful" he is referring to general success but primarily success with relationships, such as with his family members. Cody's distal future career goal (DFCG) is dual-defined. He would like to become a leader by being on a creative board of a company, and he would also like to continue pursuing his humanitarian goal by becoming involved with humanitarian projects, possibly in a non-profit organization (NPO). Cody believes his goals of being in a leadership role and being part of a humanitarian project can be combined but that having a job where he can do both is unrealistic. He considers being on a creative board a job and being a part of an NPO a side project. Overall, he sees himself in 5 to 10 years having a full-time engineering-related job and starting or being part of an NPO. To achieve his DFCGs, Cody has four well-defined DFCGs, shown in Figure 6.5.

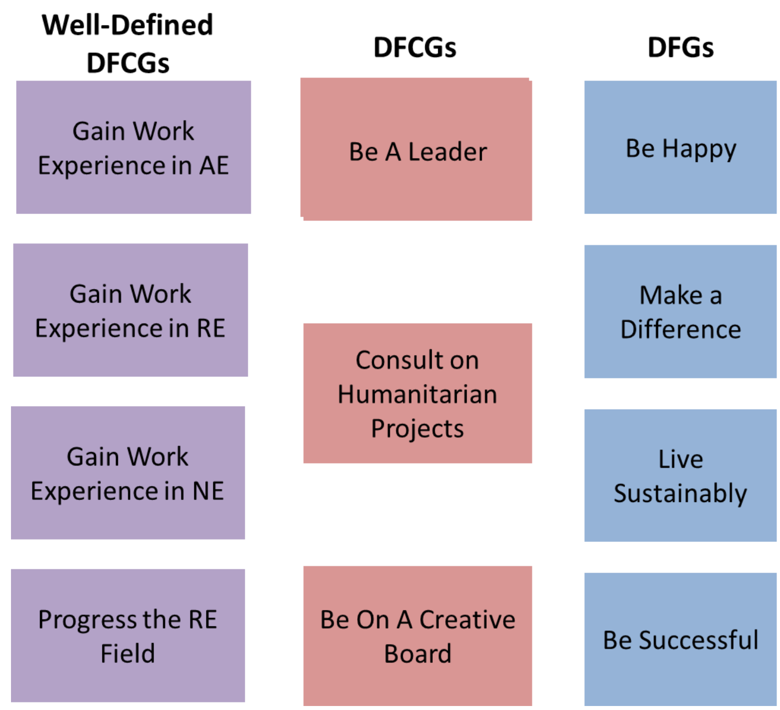


Figure 6.5: Cody wrote his DFGs (blue), DFCGs (red), and Well-Defined DFCGs (purple) on cards during the second interview.

Cody's FTP and Possible Selves Characteristics

Cody reflected on a sophomore-level ME course when completing the MAE survey in the spring. The FTP survey scores were used in participant selection, along with part of an interview addressing current qualitative FTP. His composite survey scores were high F (6.0 out of 7), high PI (5.8 out of 7), and low FoP (1.0 out of 7). The low FoP score quantitatively links to the Cake Cone FTP type; however, Cody's qualitative FTP displays classic Sugar Cone characteristics, such as well-defined career goals, a high PI for related material and courses, and a strong sense of an impact of the future on the present and vice versa. The ambiguity within Cody's three convergent RE job paths may have affected his FoP survey responses. Likely, the F scoring reflects Cody's well-defined and engineering-focused future views due to its stronger validity values and the nature of Cody's future views. Additionally, the high score for endogenous PI survey items is most likely to reflect Cody's PI of the material in his ME course as Cody reflected on a course in his major, which he feels is relevant material to his future.

Consistent with Sugar Cone characteristics, he sees his career clearly for seven to eight years and then can describe where he wants to be in ten years, as seen in Figure 6.6. Cody is avoiding a future where he writes books for a living due to his strengths in math and science. Cody said, "I think that, regardless of shortcomings, pretty much anyone can do anything if they—There's definitely a lot of people have those—I was born just—I was blessed to get a math and science." He also does not want to work a traditional "nine-to-five" job and has eliminated the possibility of pursuing goals related to being a park ranger (e.g. park certification or tourism). He also knows he does not want to be a mechanical engineer, though he selected this as his major. Cody realizes his path may change if he realizes "that it's not fun" and specifically said,

> I've been pretty much on the border between working with energy and aerospace for a little while. This summer, I had—I interviewed with [an AE company] and I interviewed with [an energy company} and I wasn't sure which I wanted to go for and ended up, well, [the energy company], like I get to stay here because I'm

> working at the county plant, and so I don't have to like worry about subleasing out an apartment that sucks anyways and this is something that—This is my number one going in. Nuclear energy is what I want to do. If I realize that that's not what I want to do, then my goals are kind of going to change, but I'm pretty flexible with whatever happens. (Cody, Interview 1)

Cody has three possible convergent paths within RE and is currently pursuing NE within the RE field. Cody is actively pursuing two of his well-defined DFCGs, as seen in Figure 6.5 and Figure 6.6, gaining experience in the NE and RE fields, by learning more about and being active in these potential paths: conducting research for a large company, pursuing relief work, or starting his own company. Cody is interested in pursuing alternative research, a position he would possibly hold if he started his own company, as it would allow him to settle down, have a family, and not travel. Whether working in management in a large company, administration of small company, or as a renewable field manager, Cody believes RE is a budding field, where those young in the field are promoted quickly and accepting management positions within just a few years due to the older professionals in the field working primarily in older forms of energy, such as gas or coal. Cody sees himself becoming a supervisor or working on a creative board in the next 5 to 10 years within the RE field. Cody describes a long FTP with well-defined steps and multiple, convergent paths leading to his possible self within RE (see Figure 6.6).

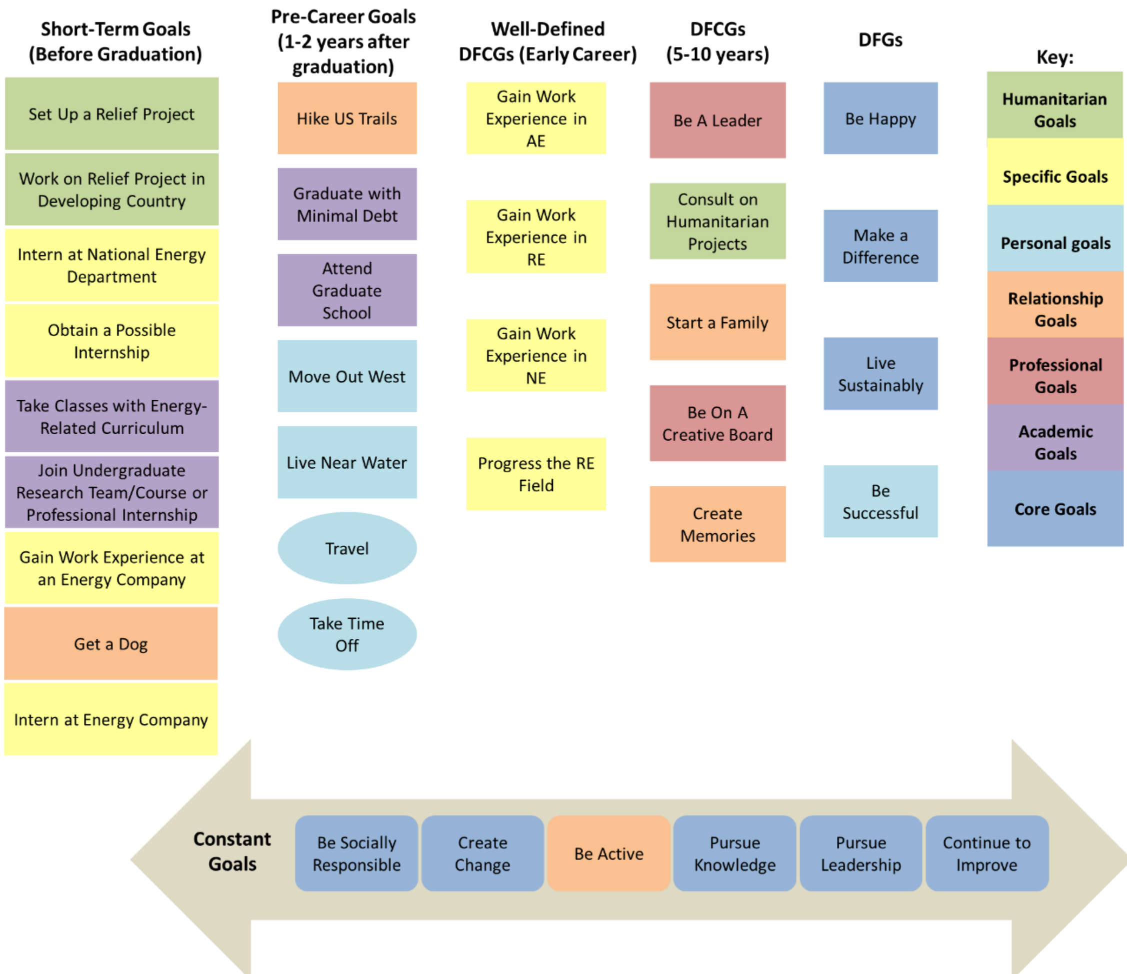


Figure 6.6: A color-coded version of Cody's path of goals from interview 2. The two round goals "travel" and "take time off" were added after Cody placed his goals into the timeline, and thus do not have a separate label in the legend.

Since Cody is currently pursuing RE, he is looking into internship opportunities related to this field. He is unclear which will work out best and motivate his career path. Due to his current pursuit of RE and a research position on a creative board, he is actively learning more about internships and has accepted a summer internship with an energy company in NE. He feels this position will help him narrow his interest within the RE field. He also plans to join a research program on a team working on energy next semester to learn more about the research side of things:

> I'm definitely striving towards research. I'm definitely striving towards getting practical experience with energy between my internship and I'm looking at doing an electrical engineering [research experience] within solar energy. You don't really get much hands-on experience inside the curriculum, so I look at me wanting to get experience with this as definitely having to reach out of what I'm forced to do in my major. (Cody, Interview 1)

His past experience on a similar research team showed him the value of interdisciplinary teams and that having multiple viewpoints is helpful in finding a solution.

Cody is also considering graduate school, as he feels it could potentially have a positive impact on his future goals. However, he does not want to attend if the program will be costly. Cody purposefully toured a local engineering company where he could work and realized a Master's (MS) degree is more tangible than he once thought.

> I went and toured [an energy company] recently and saw a couple of their programs are like, you basically do 6 month rotations through their plants while you're getting your Master's Degree. Something like that, if that was offered to me, I don't know if it's as prevalent as it was, I would definitely take. (Cody, Interview 2)

Cody is interested in pursuing an MS to be the head of projects such as a "Technical Officer" or "Chief Engineer" where he can make design decisions. However, he feels he will be able to have a similar career with similar pay no matter his degree and is only likely to pursue his MS if it is paid for by his company.

Another goal for Cody is earning a minor in Sustainability, which he has selected to justify taking courses which will support his goal of working in an NPO. While he would have considered an AE minor, his university does not offer it. Additionally, Cody feels that an AE minor may have been too restrictive, leaving too few elective opportunities and limiting his coursework possibilities. He is passionate about sustainability in his life, in the world, and in learning. Additionally, he enjoys the work, likes the flexibility of the minor, and wants to take all of the courses required in its curriculum. He is glad some of the courses that are related to sustainability are now "justifiable" through his minor.

Cody's non-academic future possible selves and his values drive his creation of career and academic goals in the present. His non-academic goals, such as "be active," "make a difference," and "create memories before settling down" are a driving force of his current activities. For example, Cody is currently involved in a relief effort project in a developing country. He is interested in pursuing humanitarian work in the future, one of the convergent paths which will assist Cody in achieving his DFCGs. He believes the humanitarian route of RE is one way to achieve happiness and to obtain his DFCGs. Cody's distal future non-academic goals are motivational for Cody, and he defines his experiences and works towards these goals:

> Honestly, making a difference is always the cliché goal, but, honestly, as long as I come home—As long as I can look back on what I'm doing and I feel like my job is worthwhile, I feel like I'm not just a cog in the machine here, then that's kind of my goal. I think I would feel better either as some sort of supervisor or somebody who's on a creative board, like something—Regardless of what my position is, I think I could be—I could make an impact, regardless of if I'm a new guy or someone who's in an administration position. Working towards those goals I guess would be continuing to pursue change. (Cody, Interview 1)

Cody's Perceptions of the Impact of his Future Goals on his Present Actions

By trying things related to characteristics he wants in a job, Cody shows a strong sense of the impact of his future goals on his present actions. Currently, Cody is pursuing the humanitarian side of things now and joining a research experience next semester. Additionally, Cody is selecting classes, such as solar, nuclear, and wind energy classes, that he feels will help him impact the environment. He believes his ME degree, will help him impact the environment "indirectly." He believes his employers will hire him for his critical thinking skills and he will use his coursework on sustainability to make a positive impact on the environment at his job. Cody believes he is currently learning how to think like an engineer, which adds to his feelings of becoming an engineer, and he believes it to be relevant to his future. Cody thinks 1) being able to do research, 2) creating change, 3) coming home feeling like he did valuable work, 4) feeling irreplaceable, and 5) using critical thinking are all characteristics necessary for his future. These are all characteristics he believes he is learning in his engineering coursework:

> Now, it's kind of like, engineering, I realize it's not just math and science and building blocks and stuff like that. It's a lot of- A lot of people will hire engineers regardless of the job, because it teaches critical thinking and being able to break down a problem into parts. I guess I'm pursuing it to continue those as well as it's actually applicable to what I want to do now, so now that I've chosen a career path that involves helping the environment indirectly, essentially, I think that engineering is the best major to go about that. (Cody, Interview 1)

Cody feels that the skills he is currently learning will be useful for his future, and he is currently pursuing experiences that will support his career and his possible selves in the future. Cody’s future goals dictate his choice of present experiences, and perceptions of the value of these experiences in terms of developing skills that will be important for his future, creates a feedback loop that is consistent with Sugar Cone traits. Characteristics he values for his DFCG are being passionate, enjoying projects, designing, being active, and gaining consulting experience. Also, Cody believes people skills, working with multiple disciplines, critical thinking, independence, self-starting, confidence, meeting people, making connections, and learning about yourself are important for his future self. He heartedly disagrees with the quote that it is "not the grades you make, hands you shake" because he believes grades, along with networking, are equally important.

Currently, Cody has a goal of graduating with at least a 3.3 GPA, which he thinks will increase after the spring semester. His experiences talking with companies, like Space X, which he is very interested in, have showed him that an ideal GPA is a 3.7/3.8 to be enticing to companies. However, he likes to set realistic goals and felt this would help him achieve his goals while still learning and remaining active on campus. To achieve this goal, he has been self-regulating, and set up a sub-path of goals to reach this proximal sub-goal for his overall GPA upon graduation. His self-regulation goals support his GPA goal, which assist in reaching his RE career goals.

Overall, Cody is a Sugar Cone due to his high motivation, clear impact of his future on his present decisions, and how much he sees his present supporting his opportunities and career in the future. He wants to be a leader in his company in five years, and in ten years be settled with a family and have moved out west. In ten years, he plans to become a member of a creative board and work on humanitarian efforts on the side, after either pursuing one of three converging paths. While Cody focuses primarily on career and academic goals, his family, lifestyle, and travel goals compliment his career path.

Openness to Change

Cody has set a path or goals based on his DFG which motivated sub-goal development, including his DFCG. Cody has then set proximal sub-goals which were motivated by his DFCG of becoming a leader in the field, consulting on humanitarian work, and holding a position on a creative board. He describes how his “end game” goals, his DFGs, will stay the same and his “constant goals,” as seen in the bottom of Figure ???, will also always be there but that all his other goals may change.

> This is kind of end-game, so this is where all of this will amount to: being happy, making a difference, [living sustainably], being successful. I think these whole things that I pursue throughout the whole time will kind of lead my goals, so my goal will change here but I think these ones along the bottom, they'll stay constant and these endgame goals will not change. Anything in here is free to change-… [My goals may change based on] any interest I have. These are things I should always be doing, regardless of whatever goals, professional small-time goals, these are all things that should happen. These could change, I ended up hating renewables and I want to be pouring oil out in the street, if I just want to go out to gas stations and just let it loose, if that's what happens these still need to be in play, but anything here is open to change. (Cody, Interview 2)

Cody’s Perceived Instrumentality of Present Tasks

Cody views most engineering-related content as valuable to his future, not just his ME courses and believes they all connect:

> I may be majoring in mechanical engineering, that may be my discipline, but I think any skill that I've used along the way kind of forwards it to—I don't think your education- Mine's not split by this is chemistry, this is physics, this is mechanical. I need to be in a mindset for each job. I think it should be everything

> you learn in school is not just a subject. They all meld together. I think that when I think of mechanical engineering, that's just thinking of part of my education, and mechanical engineering just happened to be that part. (Cody, Interview 1)

Often, this is considered a Cake Cone quality; however, Cody has dual DFCG's with a long list of skills that he feels will contribute to his success in both positons. For example, Cody believes engineers must think critically and be personable. Additionally, Cody believes in a separate set of important skills for working for an NPO, including networking and working across disciplines. Cody has a high PI for the content and skills he is learning in his classes based on his DFCG's and the multiple opportunities he sees for himself in that field. His humanitarian and research efforts support this high endogenous PI. Cody also holds a high endogenous PI for his Sustainability minor, related to his DFG of living sustainably:

> I'm learning sustainability and that's something that definitely permeates you, a lifestyle. What do you learn and differences it can make and the effects of what you do, there's something that changes the way you live, the choices you make and whether it be from recycling a bottle to, "Okay, let me figure out my finances" and you feel like this is realistic. These are things that could actually happen, that- Being more thoughtful about what you do and more critical about how you do things is something that's going to continue on. (Cody, Interview 1)

While Cody values many skills, he is more selective with what course content he believes is important. Cody sees statics, dynamics, physics, electrical engineering courses are all relevant to what he will do later. He calls thermodynamics "physics 3" because it is so relevant, and he also views heat transfer and anything related to nuclear engineering as relevant.

Cody believes that he needs certain skills for engineering that he will use for the rest of his life. He believes he will need to communicate and relate information to others and for other people, that he must understand it and then be able to translate it into simpler terms for others. His strategies for *seeking social assistance* support his ability to work with others. Cody believes he is learning important job characteristics through his courses such as research and critical thinking. Specifically, Cody believes he will use the following aspects he is learning through his engineering degree for his entire life: understanding sustainability, staying calm under pressure, being thoughtful, and thinking critically.

Cody's Use of General SRL Strategies

Cody uses most of his SRL strategies for all of his courses, and a few specifically for engineering. He learned these strategies through trial and error from the list of strategies he was taught at training for his tutoring position through the learning center on campus. He also learned some strategies from peers. Cody realized his high school study strategies were not working and he decided to make a change. Since, he has adopted strategies for all of his courses and some just for engineering-related material due to his high endogenous PI for his coursework, and through his strategies can be seen a theme of *organizing and transforming*. Cody's defined study skills when he said:

> If you have study skills, I think it means that you know A) how to get information, B) how to interpret information, and C) how to understand and commit that to a long-term memory, so not only, 'Yeah, I can recall this. I recall that this, this equals this. I can understand why that is.' (Cody, Interview 1)

The main engineering-specific strategies that Cody uses are *rehearsing and memorizing*, *organizing and transforming*, and *seeking social assistance*. He uses *rehearsing and memorizing* strategies by doing practice problems and *organizing and transforming* strategies by altering the material to know the "why" behind the problem and being able to "verbalize it." Cody describes an example of understanding the "why" from his engineering class:

> [We] were talking about sheer bending diagrams, essentially if you have beam how applying force to it will affect it and why certain things happen, so basically, it- I was trying to explain it to someone and it involves a lot of understanding of Newton's laws, a lot of understanding of how reactions work, how forces about a certain point work. That was something that I didn't fully grasp, but I knew the process and being able to expand on it and understand like, "Okay, this is actually because of Newton's Third Law and this actually happens because of reaction." Being able to actually break it down to, "Okay, I understand why this all happens." It went from my having to memorize how the forces looked and the process for doing it, too. "Okay, even if I forget the process, I know why it works

> and why it happens, so I can come up with the process myself. (Cody, Interview 1)

Cody also uses note and equation sheets for his engineering-related courses such as Calculus, an *organizing and transforming* strategy. Cody realizes it isn't enough to just memorize in engineering as he will need the material later. This distinct use of strategies for engineering, even though there are only a couple of extra skills he uses, shows the difference in how students study for engineering courses and also how Cody views the material. Cody has a high endogenous PI for his engineering coursework and utilizes the SRL strategies necessary to learn the material he feels he needs for later in his upper-level courses and for later in his career.

In his Thermodynamics course, Cody learned the process of thinking like an engineer, which involved primarily *organizing and transforming* SRL techniques, such as deciding how to label pieces of a problem:

> …it's the most relevant to me, it's thermodynamics I'm currently in. I think it's the professor, [professor name], is amazing and he's kind of taught us how to think as engineers, and since we don't have a "how to think as an engineer" course, that's kind of how I'm taking it. We do a lot of- the whole breaking down the model thing is kind of where I got that from, because what we do is kind of, "Okay, this problem you need to identify what the important parts are and what we're looking for and you need to pick a model to do it," which isn't physically drawing it, but it's like, "Okay, this applies to this, this applies to this," assigning some sort of

> characteristics to it. I think that class has influenced the most the way that I've learned and…it's kind of changed the way I've thought about different problems and attacking different things. (Cody, Interview 1)

These *organizing and transforming* strategies have altered the way Cody approaches his classes, and he reported an increase in his grades due to his use of these strategies.

In all of his classes, Cody utilizes other strategies such as *reviewing records, structuring the study environmen*t, *self-evaluating*, *seeking information*, *seeking social assistance,* and *organizing and transforming*. Cody lacks *self-monitoring and keeping records* and *planning and setting goals* strategies while studying, except for attending class regularly. Cody's definition of studying shows self-regulation in terms of helping seeking, whether in the form of *social assistance* or *seeking information* and *organizing and transforming*. Cody uses *seeking information* by looking online and using online videos.

Cody believes in not just using and reading the textbook (*reviewing records*) but also using it to concept key pieces of information (*organizing and transforming*):

> Look at your textbook and try to recall either notes you took in class today or what you've heard about this before. I definitely believe in reading the textbook before and summarizing it, but after, when you're studying, you need to be able to relate concepts, and if you can't read something in the textbook and be like, "This is what we talked about in class. This is how it was verbalized in class. This is how I wrote it in my textbook, so this is what it is. Combine and be like, this is the

> meaning," and then apply it. You need to work on being able to either interpret or stay involved in class and reading the textbook. (Cody, Interview 1)

Organizing and transforming is a theme which weaves throughout Cody's study strategies, as seen in the above statement. Even while memorizing material, Cody repeats in his own words (*organizing and transforming*) the material to others while *self-evaluating*; he also reads the textbook as a formal strategy to study but uses his own words to understand the material he is reading, again *organizing and transforming*. Cody uses these same primary skills in all his classes, including engineering and non-engineering.

While Cody lacks *goal-setting* as a strategy when sitting down to study, he sees *planning and goal-setting* as a means to a destination and describes the importance of goal-setting through a visual scenario, describing goals as a means to reaching a destination:

> I guess it's just like having a destination. I don't go out and walk ... well, actually, that's a lie. I wouldn't go out and just drive somewhere. It's very rare that I just drive, I'm not going to just waste gas. It's the same thing, you don't go out and just "do" school. You should be going somewhere, even if you don't know where you're going specifically, at least have a general direction, don't just start doing circles or something, don't just waste time. I think college is too expensive, and I think education is too important to just dilly-dally around. (Cody, Interview 2)

Cody finds goals motivation and help him keep his eyes on his path. First, he sets big-picture goals when studying, primarily for when he sits down to study so that he will look over what he missed. If he finds the time, he will study, but he does not believe that setting specific, "minutia" study goals is important. Cody described how he sets short-term goals in a course:

> I'll set them very specifically. I'll be like, “Alright, I need to get better with this program by 'X' date," and then I'll look into it and be like, "Oh, well, they actually use this program, which is like similar, like Solid Works versus like Auto-CAD, now I need to get better with this program, the other one isn't as important. (Cody, Interview 2)

For his coursework, Cody finds it valuable to set goals to have extra motivation to finish an assigning and firmly understand material. He creates sub-goals of studying to earn grades, and he sees the direct importance because of this path of sub-goals. He feels similarly in his major, but that these goals are less important because they are more predetermined by the coursework:

> My goal in coursework can be to do well, and my goal in college is to be a good student, but my major then is just like, "Alright, I want to work in aerospace, I want to have a better understanding of automobiles." It's picking and choosing what classes you want to take, so that kind of goes into the having a direction thing. (Cody, Interview 2)

More specifically, Cody believes his course goals will set him up for success in his major and other larger goals: “If you're setting these small goals in coursework and an overarching goal to be a good student then I think your major and setting goals there is now defined by your personal direction and what you actively want to do." He uses this personal direction to pick courses he knows he wants to take or that will be useful later. Cody feels setting career goals are less important as these are out of your direct control; thus, he has set sub goals related to pursuing his career such as improving his weak areas and on his strengths.

Cody heavily combines *seeking social assistance* and *self-evaluating*. When setting goals, Cody reaches out to others to check-in and self-reflect (*self-evaluating* and *seeking social assistance*) and he updates them as he gathers additional information. Additionally, he uses peers, specifically study groups, to ensure that he knows the material. To *self-evaluate*, Cody summarizes in his own words (*organizing and transforming*) while talking with other students. He often uses peers to learn (*seeking social assistance*). In particular, he has them explain class material to him, and he repeats back to ensure he has understood. Other ways Cody uses *seeking social assistance* include contacting his professors, studying with other students, and attending tutoring sessions.

Cody’s Use of SRL in Major-Required MSE Course Related to PI

Cody’s self-regulation in his courses is directly related to his perceptions of instrumentality for the course material. This phenomenon is shown through his lack of self-regulation in his MSE course in the fall. While Cody has a high PI overall, he prioritized other courses in which he had a higher endogenous PI over his MSE course. When his endogenous PI is lacking, his exogenous PI maintains some motivation to utilize the SRL skills Cody feels are necessary to obtain a certain grade goal, assisting him in reaching his current GPA goal of 3.3.

For Exam 1 in his MSE course, Cody explained in detail his lack of self-regulation (*self-evaluating*) and how he took the exam "mostly took the exam on a wing and a prayer." He detailed his use of *reviewing records, rehearsing and memorizing, structuring the study environment, planning and goal-setting,* and *self-evaluating* strategies. Cody *reviewed* the lecture notes and watched an online video, and he used “cramming” by completing a practice exam with no answer key (*rehearsing and memorizing, structuring the learning environment*). In particular, Cody set a goal of studying enough to earn at least a 60% on the exam (*planning and goal-setting*). Cody met with other students to explain topics, as a means of *self-evaluating*, but he felt like he was “pretending” to know the material and said, "In the future, honestly, my effort won’t deviate much but I will probably start fact checking what I say to other students." This lack of change in his self-regulation is likely due to a rigorous testing schedule; Cody had back-to-back exams, with another strenuous test earlier in the week.

Cody studied similarly for Exam 2 as for Exam 1, including *self-evaluating, reviewing records*, and *rehearsing and memorizing* and he mentioned his lack of *structuring the learning environment* and *planning and goal-setting*. He did "take a step back" and *evaluated* how he studied for his first exam to see if he should make any changes.

However, he did not adjust. He did not set a goal grade this time around and realized, "My goals when it came to studying for Exam 1 could best be described as 'more absent than me to my 8a.m. psychology class.'" His study situation involved watching episodes of "The Office," chatting with his girlfriend, and *reviewing records* ("module notes").

Though Cody severely lacked self-regulation for Exam 1, he appeared to be very self-aware. He realized his GPA may be declining due to his lack of preparation, and he also felt he should spend more time on the course. His time constraints and the rigorous testing schedule, which includes three exams from three engineering-related courses, hinder the proper use of self-regulatory study behaviors. Again, Cody feels his Statics and Dynamics course is the priority as an ME major. Cody also prioritizes his Physics course over his MSE class. This set of priorities hindered Cody's goals and self-regulation for the MSE course.

For Exam 3, Cody utilized *rehearsing and memorizing* (practice exam), *self-evaluating* (checking practice exam answers, reconsidering study skills) and, again, lacked *structuring the learning environment* (watched movie while studying) and *planning and goal-setting* strategies. Unfortunately, Cody set minimal, or no, goals for this course during exam study periods. Over time, Cody has called his week with three exams in his Statics and Dynamics course, Physics with calculus course, and MSE course "hell week." His schedule allowed him some relief on his third exam and MSE was his only exam in a single week. Cody showed test anxiety due to his lack of self-regulation in MSE because of his prioritizing the other exams, and in his Exam 3 reflection, he said, "I was able to actually study without the crushing weight of possibly having to retake Statics and Dynamics looming over me this time around." While he did a better job studying, he accidentally forgot to study an entire topic worth 7 points on the exam, something that may have been alleviated by *planning and goal-setting* techniques. Overall, he was happier with his self-regulation (*self-evaluating*) because he felt "these new found study habits were enough to put me in the 'still redeemable' range for my Materials Science grade, which is perfect."

In the fall semester, Cody clustered as a Cake Cone during the analysis of the MAE survey responses, with composite scores medium F (3.75 out of 7), high PI (7.0 out of 7), and low FoP (1.5 out of 7). Cody reflected on his first exam SRL strategy use at that time. Cody scores a high endogenous PI for his MSE course but voiced a lack SRL skills. He prioritized other courses above his MSE course. However, Cody demonstrated several aspects of self-regulation in regards to getting ready for his exam. Cody disclosed that he had three exams during the week of his first exam in his MSE course. As an ME, he prioritized the other two classes, Statics and Dynamics and Physics, which he feels are more relevant to his major, over his MSE course. This prioritization caused him to use weaker study habits. While using less skills, and time, than he said he would like, and likely less than on his other two exams that week, Cody has learned how to prioritize courses, a very self-regulated tactic. However, Cody does appear to lack some time management skills (*planning and goal-setting*) which would serve him well in this type of situation.

Cody underutilized *planning and goal-setting* strategies in his MSE course, primarily due to his rigorous exam schedule. The first exam, he wanted to make above a 60; the second exam, he didn't set any goals; and finally, the third exam, he set the goal of having a catch-up study time for the final to make the grade he needs. He was able to study more due to a better schedule that week (no other exams). He *self-evaluated* when looking back and mentioning that he could have done much better ("aced the course") if he had put in more time and effort. Cody summarized his self-regulation for the third exam, which illustrates his goal for studying for the final exam in his MSE course:

> That is what I accomplished on [Exam 3]; my goals guided my studying in a way that allowed the lackadaisical amount of effort that puts me probably at exactly an 86 for this exam. With just enough distractions, I’ll be sure to get an 88 on the final, leaving me with a B in the class, just two points short of a perfect Cinderella story. (Cody, Journal 3)

Connection of Cody’s FTP and SRL Strategy Use

Cody’s strong endogenous PI for current tasks and courses supports his use of SRL strategies. His endogenous PI is noticeable for his engineering coursework and relates to his future goals when he explained how he will utilize what he is learning about sustainability as part of his lifestyle. In fact, Cody believes he will use engineering his entire life professionally and personally by using his critical thinking and sustainability skills. He believes his statics, dynamics, physics, and electrical engineering courses are all relevant to what he will do later. He calls thermodynamics "physics 3" because it is so relevant. Also, Cody sees heat transfer and anything related to nuclear engineering is relevant.

Cody developed his study skills, especially those related to communicating, through his experiences due to his focus on “looking ahead” to his future and realizing what would be important for that future. For example, his classes such as senior design, technical writing, and fluid mechanics involve group work and other projects which need strong communication between members. Cody thinks the study skill of “understanding by communication” is important for this.

Cody sees learning and studying in multi-disciplinary teams in his engineering program as related to his future goals. In his current humanitarian efforts, Cody works on multi-disciplinary teams, not engineering-only teams. He feels the ability to work on multi-disciplinary teams will be vital to his career. Cody also believes it is important to be able to talk about data, interpret it, and find information, as he defines study skills. These are SRL skills that he is developing through studying in his courses, and he thinks he will use these skills in later courses and in upper-level with communication while working with other people. Specifically, Cody will have to similarly process information by talking about it, interpreting it, and finding new information, in nuclear energy. Cody believes *seeking information* will be a vital skill in his future career.

Cody's endogenous PI for his course material supports his *seeking social assistance* and *seeking information.* He believes these two SRL themes are skills that are valuable to learn through college and then will apply in engineering in the workforce. In particular, he looks for course support from his professors and students in his classes, especially in engineering-related courses:

> I really like getting to know the professor. That was something in high school that I did, that I didn't really bring to college until this semester, and I really like that. I want to be able to get to the know the professors, make those connections. I want to get to know the students in my class, make those connections as well. My goal is to just remember after a semester or two after the course, because that's my big problem is just learning it and then forgetting, so being able to still apply it and continue applying it would probably be my biggest goal in my courses, and then to do well, obviously. (Cody, Interview 1)

He realizes he will need material in future classes and in his career which he has already learned, and he additionally uses seeking information, such as YouTube, to keep related information fresh:

> Then, I just have noticed myself physically in these later courses, where I need to know stuff from earlier courses, that I've already forgotten, so making sure you retain that. I'm officially to the part where I'm learning useful things so it's gotten to the point where it's like, this is something I'm going to use in my career, in my

> future, pretty much regardless of what I do, so this is something I want to make sure I memorize.

Cody also sees the skills of communicating that he is developing from learning and studying in his engineering program as related to his future goals. For Nuclear Engineering in RE, Cody believes he must be able to find information, interpret it, report back, explain it, etc. He needs to be able to utilize *organizing and transforming*, *seeking information*, and *seeking social assistance* strategies to talk about data, find related information, and interpret it. Cody also thinks he will use these skills and related engineering material in later courses and further in his career with communication and working with other people.

Cody connects his future goals to his self-regulation in the present. Cody strives to connect with his professors and other students in his course because he sees value in this for the future. Additionally, he decides to use *rehearsing and memorizing* when he realizes he forgets material in his courses quickly:

> I'm officially to the part where I'm learning useful things so it's gotten to the point where it's like, this is something I'm going to use in my career, in my future, pretty much regardless of what I do, so this is something I want to make sure I memorize. (Cody, Interview 2)

This viewpoint of Cody’s is linked to the value he sees in his current courses. Additionally, this motivation is caused by his experience with material and what he views as essential to his future. He has experienced examples of information at play in the real world that he learned in class, such as learning about turbines and then seeing them at his tour of GE. For new, important information, which Cody views as instrumental to his future, he uses *rehearsing and memorizing*, *seeking social assistance*, and *seeking information strategies*.

Cody's Description of Success and Failure

For Cody, success is feeling like he did not waste his time, whether that relates to the money he makes or the amount of work he has done. Primarily, he feels successful if he can provide "emotionally, physically, or monetarily" for himself and those in his life. Cody says he would feel most successful professionally reaching his humanitarian project goals and personally by creating good memories: "I think that having those memories is a sign that you were successful, that you met people, you had an effect on people and you let people effect you." Alternatively, Cody believes that failure is not being passionate about what you're doing; he has a wide range of passions which were revealed when he said, "For me, [failure and success are] black and white, but for the black and white thing, the black is very small and the white is- It's a really broad definition for success." In terms of studying, Cody sees his success in his grades and compares his capabilities with the difficulty of the course; depending on the difficulty level, a successful grade could range from a C to an A in a particular course.

The Creation of Cody's Path of Distal Future Goal, Distal Future Career Goal, and Proximal Sub-goals

During the spring interview, Cody labeled his goals, as seen in Appendix R by grouping them into like sets: Core, Professional, Specific, School, Family or Social, Personal, and Humanitarian Goals. Then, Cody set these goals into a path, as in Figure 6.6, with his proximal sub-goals lined up in a timeline to reaching his DFGs or "end game goals." which he described as:

> This is kind of endgame, so this is where all of this will amount to: being happy, making a difference, being successful. I think these whole things that I pursue throughout the whole time will kind of lead my goals, so my goal will change here… (Cody, Interview 2)

While creating this path, Cody added the "personal goals" cards: "travel" and "take time off." Cody is currently pursuing his "constant goals," which are seen along the bottom of his timeline in Figure 6.6 and are designated in Figure 6.7. Cody considers his "constant goals" as a means to meet his four DFGs.

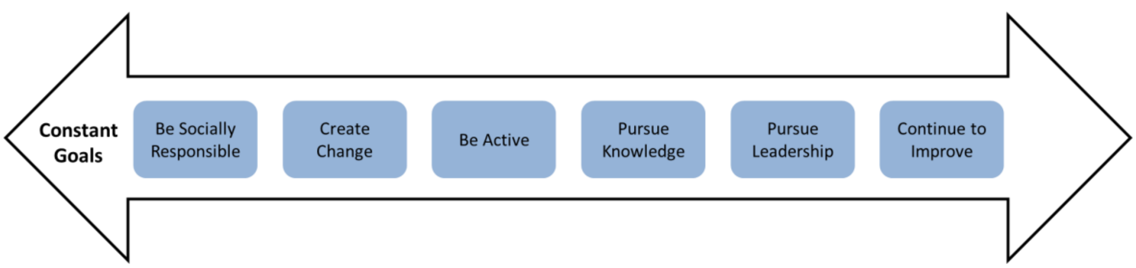


Figure 6.7: Cody's "constant goals," which plans to pursue throughout his entire life.

Cody's DFGs determine the status of his path and any changes he makes. Cody shows a large FoP by discussing his ability to change his path and the reasons behind it. Cody said, "If I decided I don't like renewables, I could take renewables out. Or if I decided that being on a creative board isn't want I wanted to do, I just wanted to like a partner in a project, just kind of work on something, take that out.” Primarily, his “be happy” goal plays a large part. Cody is currently pursuing, in late spring, his “constant goals,” as a means to meet his four DFGs. Also, he is currently pursuing his relief effort project-related goals: “Pursue classes in energy related curriculum” and “join [another] Creative Inquiry.” He considers signing up for a you-pick internship equivalent to a CI. His next move is to work at an energy company for the summer. His steps of “constant goals” leading to his DFGs and the motivation to set up his relief effort project goals and complete internship experience shows a strong connection between his present and future. He has created a path of goals leading to his DFG, including current goals and “constant goals.”

Relatedly, Cody's DFGs have motivated the creation of his "between goals" to get to his "by 30 goals" and then onto his "end game goals" because he believes his "between" and "by 30" goals will help him achieve happiness and the other three DFGs. Cody realizes the some of his goals may not be as important, but he wants the experiences, including hiking specific trails, living out west, working in different fields, etc. However, due to the motivational nature of Cody's DFGs, he believes some of his goals are removable, and thus non-contingent to the completion of Cody’s path: “attend graduate school,” live by a body of water,” and “be on a creative board.” Again, Cody has a strong sense of FoP as he realizes goals, such as finishing graduate school, are not necessary to keep him on his desired path.

Cody realizes that experience in his field are more important than GPA and degrees. He is continuing to set himself up for success, such as keeping up his GPA in case he decides to attend graduate school, but this is to keep his options open. He realizes his future success is not contingent on a graduate degree, and he will be able to continue on his path of goals without this specific PSG. Cody is setting himself up for goals that will keep him on his path, leading eventually to his "end game goals."

Strategies for completing the proximal sub-goals in Cody's path

The complete list of the strategies Cody uses to pursue each of his goals in his path are in Appendix R. Cody's "constant goals" are strategies which serve as strategies and sub-goals for his "end game goals," also listed in Appendix R. The strategies for his "constant goals" are unlisted as Cody did not provide them. However, since Cody explained that he will always be pursuing these, everything he works towards is a strategy set to achieve his "constant goals," which in turn support his "end game goals." Relatedly, three key SRL themes occur within Cody's strategies related to his PSGs: *seeking social assistance*, *seeking information, and planning and goal-setting*. While themes related to SRL, such as *organizing and transforming* do not make sense in this context, some others such as giving *self-consequences* may but are unlisted.

Cody directly listed strategies of networking or making connections, which are considered *seeking social assistance* as Cody hopes to network to learn more about the goal he seeks to achieve. These strategies are included on 11 goal cards, including his DFCGs "be on a creative board" and "consult in humanitarian projects" as well as his related long-term goal of “be a leader in the profession.” The goals of gaining experience, which are PSGs created to support his DFCGs, also have these strategies listed. Finally, Cody’s more short-term goals of interning, setting up relief projects, and conducting undergraduate research all list *seeking social assistance strategies*.

Several of Cody’s goals have a form of “research” listed as a strategy. Since Cody intends to find out more information to be successful in achieving the goal, these strategies are considered *seeking information*. Cody plans to look into, or research, graduate schools, US hiking trails, adopting a dog, areas he may relocate to, and relief work on the developing country project. While setting these goals may be considered planning, Cody more intentionally utilizes the SRL theme of *planning and goal-setting* when listing “scheduling” as a strategy in reaching his goals.

Cody’s GPA goal, which is to have a minimum of a 3.3 upon graduation, is directly related to his DFG. To achieve his GPA goal, Cody has been self-regulating by attending office hours (*seeking social assistance*), studying with others (*rehearsing and memorizing and structuring the learning environment*), and working practice problems and exams (*rehearsing and memorizing, reviewing records*). He utilizes other strategies as listed in the Self-Regulated Learning section and in the Table ??? above. Relatedly, Cody has “keep GPA up” as a sub-goal for many of his PSGs: “attend graduate school if an offer,” “intern with [one of two energy companies in an RE position],” “[gain] work experience in RE,” “[gain] work experience at an energy company,” and “gain work experience in AE.” These career-focused PSGs are part of the convergent paths that lead to Cody's DFCGs. Cody's DFCGs support his DFGs; in fact, Cody's DFGs motivated him to create DFCGs which would help him achieve his DFGs. Thus, Cody's DFGs motivated the development of a set of PSGs which lead directly to his GPA goal and thus his use of SRL strategies in the present. His self-regulation goals reach his 3.3 goal, which assist in reaching his RE career goals.

Cody's Connectedness for Sub-goals in Path

Table 6.3 shows how important Cody's goals are to his DFGs on a scale of one to ten, a connectedness score, and which DFGs are included in this connectedness rating. Again, Cody has four DFGs, which he rated in order of importance as I) be happy, II) make a difference, III) live more sustainably, and IV) be successful, Cody did not place a connectedness score on any of his "constant goals." However, he is continually pursuing this set of goals to meet his "end game goals," which are his four DFGs. Additionally, Cody's goal of "[obtain a] possible internship" was not included as by his second interview in the spring, he had completed this goal by agreeing to intern at an energy company.

Table 6.3: The Connectedness score placed on the goal in the left column in reaching the goal in the top row during Cody's path creation in Interview 2.

Goal	Connectedness Score	Related DFG
Intern with [one of two energy companies in an RE position]	3-4	"Make a difference," "Live more sustainably"
Attend graduate school if an offer	4	"Make a difference," "Be successful"
Live in Charleston (or by some body of water)	4	"Be happy"
Set up relief project through [university]	4	"Be happy," "Make a difference,"

		"Live more sustainably,"
Work on relief work for developing country project	4	"Be happy," "Make a difference," "Live more sustainably"
[Gain] work experience in nuclear energy	5	"Be successful"
[Gain] work experience at an energy company	5	"Be happy," "Live more sustainably," "Be successful"
Progress the renewable energy field	5	"Make a difference," "Live more sustainably," "Be successful"
[Intern at an energy company] ([next summer])	5	"Be happy," "Live more sustainably," "Be successful"
Do classes in energy-related curriculum	6	"Make a difference"
Join another [Undergraduate Research Team/Course] or do undergraduate research/[Undergraduate professional] internship	6	"Be happy," "Make a difference," "Live more sustainably," "Be successful"
Hike the [US trail]	6	"Be happy," "Live more sustainably," "Be successful"
Be on the creative board	6	"Be happy," "Be successful"
[Gain] work experience in aerospace	6	"Be successful (as a whole but primarily relationships)"
Consult in humanitarian projects	6-7	"Be happy," "Make a difference," "Live more sustainably," "Be successful"
Travel	7	"Be happy," "Live more sustainably"
Take time off	7	"Be happy"
Hike the [US trail]	7	"Be happy," "Live more sustainably," "Be successful"
[Gain] work experience in "Renewable energy"	7	"Live more sustainably," "Be successful"
Get a dog (also "Get a new best friend")	8	"Be happy"
Move out west (because [where he lives] is hot)	8	"Be happy"
Be a leader in profession	8	"Be happy," "Make a difference," "Be successful"

Create memories before settling down	9	"Be happy," "Be successful"
Graduate with no/minimal debt	9/10 graduate, 6 no/minimal debt	"Be successful"
Start a family	10	"Be happy," "Make a difference," "Be successful"

Cody's most important goals in fulfilling his DFGs rate 8, 9, and 10. Cody's goal to "start a family" is his only goal ranked as a 10, showing his connection between that goal and his DFGs of "be happy," "make a difference," and "be successful (as a whole) (but primarily relationships)." These three DFGs are wholly contingent upon his obtaining and fulfilling his family goal. Additionally, Cody believes his current path of goals may only be met if he can graduate, as he rated the "graduate" portion of his goal "graduate with no/minimal debt" as a nine out of ten in reaching his DFG "be successful." Cody rates the importance of creating memories as a nine out of ten to meeting his DFGs of being happy and successful. Becoming a leader in his field is also important to his happiness, success, and ability to make a difference. Finally, Cody believes getting a dog and moving out west will contribute significantly (eight out of ten) to his happiness DFG.

FTP Characteristics and Connections to SRL Elicited from Cody's Path

The connections between Cody's FTP and his SRL strategy use are depicted in Figure 6.8. Cody has a strong sense of his possible selves, related to his four DFGs: being happy, making a difference, living sustainability, and being successful. These four goals are a driving force for Cody's path of proximal sub-goals. Thus, Cody has envisioned a future career, specifically becoming a member of a creative board to do research, be a leader in the field, and work as a consultant in humanitarian efforts on the side. This DFCG is flexible, and Cody will update this goal, thus altering his path of proximal sub-goals, if he finds he is not meeting his DFGs through this current path. This flexibility and possible update of his DFCG is shown by the feedback loop in Figure 6.8 between his DFG and DFCG. His DFCG further motivates the creation of short-term proximal sub-goals, including sub-paths of three convergent RE positions stemming after graduation. During his time at the university, Cody is setting himself up for relevant experiences, such as research and internships, where he may build skills, including SRL strategies such as *seeking information*, and firm up course content. These experiences and Cody's goal of obtaining an RE position upon graduation motivate his minimum GPA and graduation goals. These two goals are a driving force for his exogenous PI for all of his courses and assists in his prioritization of SRL behavior use in his less valued courses. Cody's DFGs, DFCGs, and path of PSGs heavily motivate his endogenous PI and cause Cody to prioritize courses he feels are more relevant to success in his future career. Finally, Cody's exogenous and endogenous PI motivate activation of Cody's SRL behaviors depending on his coursework, as seen in Figure 6.8, with selective strategies utilized for engineering-related courses based on this PI. While Cody believes transferable skills are essential to education, he feels that grades are the way in which he knows if he learned the material in a class. He stressed the importance of grades when he discussed how a test may be reflective of his success in a job,

> Look, college is great for the experience and everything, but if I don't leave with a degree, I'm not going to be able to- I can't be a nuclear engineer without a college degree. I can't work in research and stuff like that without a college degree. While

grades may be some, like some people say, an arbitrary ability- or an arbitrary measurement of your ability to take a test, they're extremely important and you need to be able to do well. Sure, people say you'll never take a test, but you will still need to be able to take those problems and get them done, like send a response back or send some sort of solution back to a customer or another person you're building with within a certain amount of time. While it's not going to be like, "Okay, I need this back in 90 minutes" it might be like, "Hey, here's a complex problem. Can you get me a quote or a solution or sometime within a day or two?" That's something you still need to be able to do. While it's not like a graded test, it's still a test that you need to be able to pass. (Cody, Interview 1)

He has struggled in the past with using successful SRL study strategies and said,

> Test grades where I got too confident in the material and I thought what I was doing just in class was enough. I didn't keep those study skills that kept me successful before, and then my grades noticeably dropped. (Cody, Interview 1)

However, he is now motivated by his grade goals to achieve success in studying by being self-regulated, and he reiterated SRL strategies he is using,

> I've just been on top of my grades, making sure I'm checking up, going to office-hours a lot more than I have before, not just for class but for things outside of class to make sure I build those relationships and am applying what I've learned

> outside of class. Then just studying, seeing when I can use stuff and when I can teach people outside of that class block. (Cody, Interview 2)

Overall, Cody is “on top of his grades” due to his grade goal of a 3.3, and he is using these grades as a feedback mechanism to evaluate and update his use of SRL strategies in his courses.

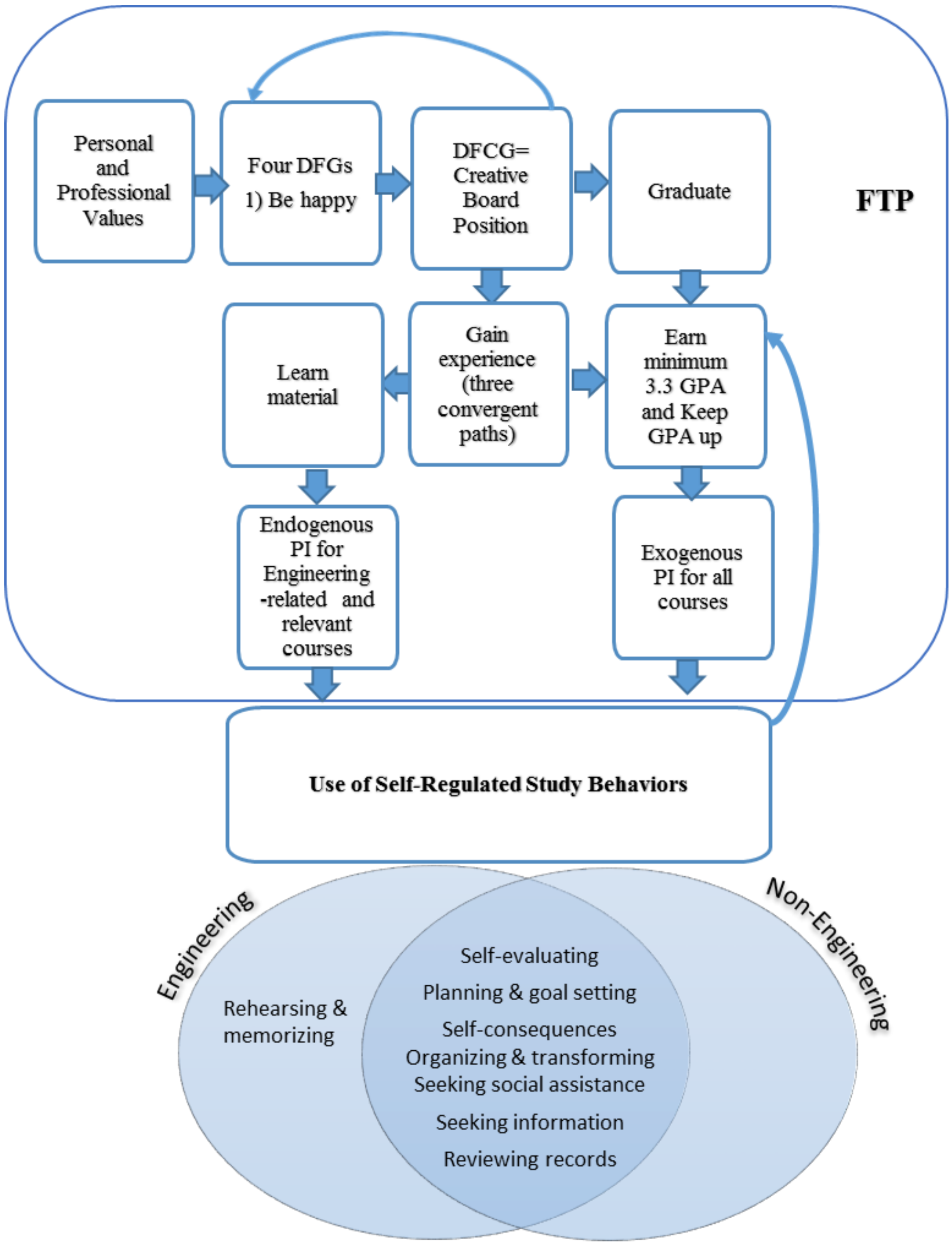


Figure 6.8: A model of the connection between Cody's FTP and his use of SRL strategies in the present.

6.3.3 Case Study 3: Greg

Greg is a second-year materials and science engineering (MSE) major and a Caucasian male. He wants a career after he graduates college which uses what he has learned in his MSE courses, helps him live comfortably, and that he enjoys doing. Greg feels that engineering is "working with what you're making" and may include figuring out how to make the product, what materials to use, and cost effectiveness. He has narrowed his interests to glasses or ceramics, as these specialties really "called" to him through everything he has learned in college. He has ruled out the polymers side of MSE, as the inorganic side appeals more to him. Greg does not plan on attending graduate school. In ten years, he would like to have an MSE position within a company and hopes to gain enough experience and make enough progress to eventually rise as a leader and decision maker in the company (Greg's DFCG). As long as he ends up liking it, Greg plans to stay in an engineering-related profession until he retires, but he realizes that since he hopes to move up that his position may slowly incorporate more business aspects. He considers business "selling what you're making." Also within ten years, Greg wants to have a family, and says that this is very much the big goal for his personal life. He wants to be a father and be able to financially provide for his family. Greg is sure that he can attain all of his personal and career goals.

Past Experiences

Greg decided to go to college based on seeing his parents' and other relatives' success. His cousins are all graduating or post-graduation, and he has used them as role models. In high school, Greg attended an introduction to MSE camp for a week and he learned a lot about the field and practical applications. This camp piqued his interest in engineering, but he was still unsure about chemistry, an important aspect of MSE. His positive experience in chemistry classes his first year in college assured him that he would like the chemistry side of MSE. He knew he enjoyed math and then his introductory MSE course in the fall was his favorite course, solidifying his interest in MSE as a career path.

Openness to Change

Through the fall and following spring semesters, Greg has a DFCG of being in a leadership position as an MSE in industry, but he is open to change. He currently wants to have a career in MSE, which uses the information he learned in his major, but he is in between two options, glasses and ceramics. He realizes he doesn't know enough yet to pick between the two. Additionally, Greg realizes that as an MSE he has an opportunity to work with mechanical engineers and other types of engineers, as his field overlaps with several other engineering roles. This will provide knowledge about other engineering roles and will help support his selection of MSE. His focus on becoming a professional engineer in MSE shows his dedication to his DFCG. Also, he is open to other options to ensure he is enjoying his job, which relates to his DFG, "being happy."

> I'd like to stay in the field I'm majoring in and just do what I actually like, so if 10 years down the road I find I want to do something else, I want to be able to move into something. I don't just have to go to work every day- I have to get to go to work every day. Enjoy my job. (Greg, Interview 1)

Greg's Distal Future Goals

Based on his survey responses in the fall semester, Greg was characterized as a Sugar Cone FTP type (see Chapter 1 for details) with a DFCG of becoming an engineer in industry in the MSE glasses and ceramics field within eight years and a lead engineer in the same field within ten years, as seen in Figure 6.9. In early spring, Greg was working to keep up his grades, obtain an internship, get a co-op for the next spring, and learn through experience to pursue MSE after he graduates. When interviewed later that same semester, he was still pursuing those same goals and clarified his DFG: "be happy." His DFCG remained constant from the fall to spring semesters. Greg feels he has not had any relevant

Figure 6.9: Greg has a clear path of working MSE in glasses and ceramics, moving into a leadership position, and meeting his DFG of "be happy." He wrote his DFG (blue), DFCG (red), and more short-term DFG (purple) on cards during the second interview.

experience to working in industry up to this point as his only previous job experience was working in fast food. Because he wants to progress in his field into a leadership role, he prefers to do a co-op and gain relevant experience, even if it means he pushes back graduation a semester. He is hoping within the first five years in his post-graduation job he will take on more of a leadership role, even if just as a team leader, and he hopes to hold a leadership position in ten years. While he doesn’t know now what the different job titles are and how to move up the ladder, he is confident his work ethic and ability will help him accomplish his goals.

Greg’s FTP and Possible Selves Characteristics

In early spring, Greg reflected on an introductory CE course when completing the MAE survey. His composite survey scores were high Future (6.25 out of 7), high Perceived Instrumentality (5.6 out of 7), and low Future on Present (2.5 out of 7). This scoring sets him in the range of Cake Cone but his interview 1 showed Greg to have classic Sugar Cone characteristics, such as well-defined career goals, a high Perceived Instrumentality (PI) for related material and courses, and a strong sense of an impact of the future on the present (FoP) and vice versa.

In particular, Greg has a well-defined and long FTP with a single path of goals leading to his possible self as a financially stable, happy engineer in MSE. His clearly defined goals, singular path, and deep extension support Greg’s choice of relevant current MSE experiences, and, in turn, Greg is using those present experiences to clarify his path and continue working towards his DFCG and DFG. Greg can connect how the content and skills he is learning in the present are useful for his future goals, confirming his high PI MAE score.

Greg's Perception of the Impact of his Future Goals on his Present Actions

To meet his DFCG, Greg is setting himself up with experiences in the present to gain valuable skills and to learn more about the field and his possible positions within industry. Greg's path of goals leading to his DFCG and DFG is depicted in Figure 6.10. Greg is pursuing an internship which would also give him the relevant experience he's looking for. Most engineering students, including Greg, attend career fairs to learn more about internship and co-op options, with a chance of interviewing with companies for positions. While attending a career fair, Greg solidified a manufacturing internship with a large steel company in the US for next summer. He feels this opportunity will give him relevant experience, as the processes related to steel are relevant with glasses and ceramics:

> From the intro to MSE class, steels, and ceramics, they're actually fairly similar, it's just, you have like your main metal element or whatever, and then you're putting stuff in there, and ceramics, you're just putting different elements together, so I guess... the same like broad, general processes so I'm still learning more about material science, it's just not specifically about glasses, and ceramics right now, but I think, that this will give me a good experience to make sure material science is the right field, and then I can specify, more of that after this internship I hope. (Greg, Interview 1)

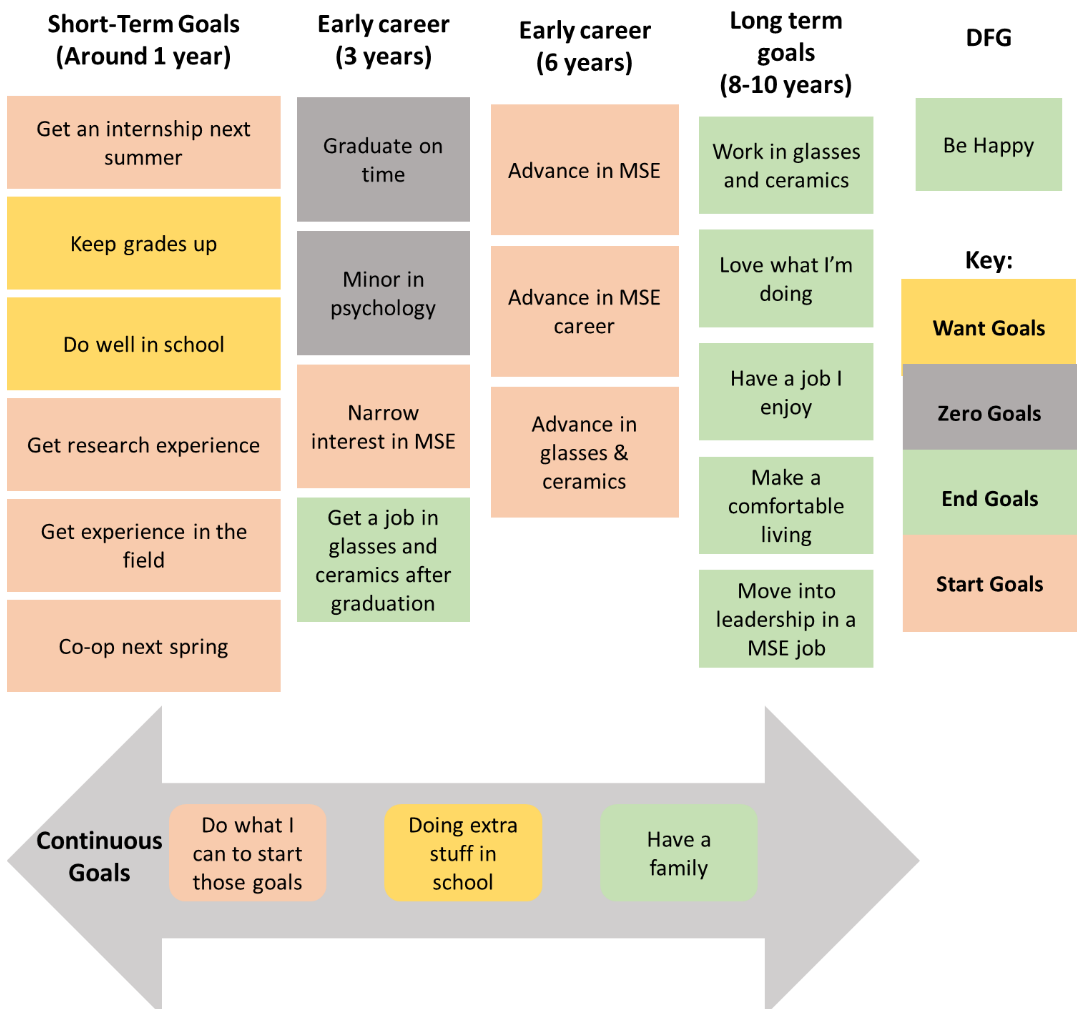


Figure 6.10: A color-coded version of Greg's path of goals from interview 2 including a legend for the four Greg-defined groups of goals.

MSE is broken into organic and inorganic and the coursework for steel versus glasses and ceramics is the same and so the experience will be valuable for his future MSE career. Greg wants to begin with a research-based or "hands-on" engineering position and then transition to a leadership role later on. Greg believes the large steel company in the US position will help him learn skills he needs in the future in both the research and leadership roles.

> [A large steel company in the US] doesn't work with the steel or create it. The higher up you go, the less you do hands-on engineering—you make more decisions or development. You may do research but not applying engineering. The business-related position is more leadership oriented. (Greg, Interview 2)

Greg did talk to other companies, including companies in glasses and ceramics, about internship possibilities but there were a limited number. By speaking with these companies, Greg learned that figuring out what is going on in the field is essential. He thinks talking to other companies at the career fair will help him possibly land a later job. He feels this internship, along with his inorganic class about metals, glasses, and ceramics, will help him determine through real world experience if he 100% wants to stay in glasses and ceramics.

> Then a lot of the people that I talked with at the career fair said that manufacturing experience is very important no matter what field you're going into. That hands-on experience, that knowledge of actually what's going on, how things are being made, and then with that knowledge, I feel like I'll be able to apply it. If I go into a steel field or something like that, I'll obviously be able to apply it. I think the manufacturing aspect and just getting a feel for what's happening in those kinds of industries will be applicable to ceramics and glasses as well. (Greg, Interview 2)

To gain relevant field experience, Greg is looking into doing a glasses and ceramics co-op starting the next spring. His institution runs a bi-semester co-op system which runs for a total of six semesters, with three semesters working at the co-op and the other three taking classes. Since Greg plans to start the next spring, he would be working for a company during three semesters: spring, fall, and summer. The other semesters, he would be taking classes. Greg has a particular glasses and ceramics company in mind, but internships with this company are very competitive. Greg is hoping that his internship with the large steel company in the US, other relevant experiences, good grades, and interview skills will land him the co-op. While he is not completely ruling out steel, he prefers glasses and ceramics, and therefore prefers to co-op with a company that focuses on glasses and ceramics. Greg thinks content as well as skills he will learn in college and during these field experiences are relevant to future and says, “Your work ethic, your organization, your time management is going to affect how you do in your field." Greg believes the skills he will learn in his internship at the large steel company in the US will be transferable to his future job:

> That hands-on experience, that knowledge of actually what's going on, how things are being made, and then with that knowledge, I feel like I'll be able to apply it. If I go into a steel field or something like that, I'll obviously be able to apply it. I think the manufacturing aspect and just getting a feel for what's happening in those kinds of industries will be applicable to glasses and ceramics as well. (Greg, Interview 2)

Along with internship and co-op experiences, Greg plans to use his elective courses to help him narrow down what he wants to do in the field. For example, Greg had the choice of selecting organic or inorganic chemistry and was selective and strategic in his choice. He chose inorganic chemistry, cutting his choices in the field in half and honing into metals, glasses, or ceramics as his area of interest within MSE. Greg specifically explained:

> I guess if I just have a choice between different classes, I want to do the one that interests me more and might more tailor to my interests. If senior year I could do a lab or a research thing dealing with steel or dealing with glass, I would do the one with glass. It narrows down to that particular field of glass so I can see do I really like this or do I not like this. Right now I just have a broad understanding of everything. If I do more of a specific glass, I'll be more exposed to the details of that particular. I can decide if I do still like that or if I want to just steer away and do something a little different. (Greg, Interview 2)

Greg has goals for what he would like to be doing at the one, three, six, and ten year marks after graduation. In one year, Greg would like to be honing his interests before graduating and starting an entry-level engineering position:

> Continue to keep my grades up, actually having fun in college, doing well in class, studying. Hopefully I will have a co-op, an internship. That will be 3 weeks from now hopefully unless something happens. The research experience would be either right after the co-op or right after graduation. Experience in the field would

> be during the internship and co-op. Learning about the field would go in that as well as narrowing interest in MSE. Through the internship and the co-op, I'll get experience, learn about the field, and hopefully narrow my interests. (Greg, Interview 2)

In an entry-level role about three years from now, Greg wants to create materials rather than research them. Greg expects to look to his supervisor for what he should be working on and to make decisions for him in his entry-level position. Between 3 and 6 years, Greg wants to advance in the company. Then, within 8-10 years when he moves into a leadership role, Greg will know what to do in his role, make decisions for direction, and be able to make decisions for others in the company.

Greg's Description of Success and Failure

Greg believes success in studying is learning the information and that his grade should reflect his understanding. Overall, Greg feels success is meeting your own expectations and described success when he said,

> [Success is] doing better or as good as you expected. Success really depends on what you think you can do and if you do, if you set your standards high then success will be pretty good, if you set them low you might succeed in your terms but not in other peoples' eyes. SO I think if you set your expectations or your standards high, then you'll succeed if you reach those. (Greg, Interview 2)

Alternatively, Greg defines failure as not meeting his own expectations, especially in terms of grades. He said,

> [Failure is] not doing how you think you want to do, you go into a test and you're expecting an A, and you get a high C, for some people that isn't an F, and some people might have been aiming for the C, that doesn't meet your expectations or what, I think that is failure, what you think you can do and if it's lower than that…

General SRL Strategies

Greg utilizes all ten SRL themes (see Chapter 2). He believes you can learn how to study from study skills classes and friends; although, he feels that learning from friends means more as it is "personalized" (Greg, Interview 1). Greg did not mention learning skills from professors, even though he specifically mentioned using strategies his professor suggested when studying for his exams. Greg also thinks it takes self-motivation to learn how to study and to put the strategies into practice, and that often he and other students must fall behind before they will seek out help to learn new strategies. Greg finds material easier to learn and study if it interests him. He can more easily recall interesting material later, even with just a quick refresher. Greg says,

> I feel like I've figured out what works best for me over these past semesters in college and use those for each class. I figured out what kind of class it is, do I need to do the text book readings or do I need to do example problems. And I'll use what study skills I know for that type of class. (Greg, Interview 1)

SRL in Concept Versus Content Courses

Greg categorized his courses as either “understanding” courses or “memorization” courses. For his “understanding” courses, he has to apply what he knows to problems rather than regurgitating information after memorizing it. Greg relates “understanding” to concept-heavy courses, such as organic chemistry and statics, and “memorizing” to information-heavy courses, such as psychology. Greg feels that understanding material will help him remember material later in his engineering job and described his engineering and other engineering-related math and science courses to his MSE career as “understanding” courses.

> Understanding, that was a big topic for my math and my statics classes because you couldn't memorize what was happening in the class. You had to understand what was happening. On the test, you're not going to be given the same problem. You're going to be given something different and you have to apply what you know to that problem. I think my statics class, my teacher did a very good job of she would present something in class and present how to solve it. Then on the homework she would give those concepts, but in a different way. Then on the test she would give it a different way as well. By that time you had learned how to apply what you've learned to the problem and actually figure it out. Psychology was a lot of memorizing as opposed to learning the concepts. There was just highlighted vocab words you needed to know. There was a couple concepts, but a lot of it was just memorizing information and facts… I feel like understanding sticks with you longer. In a year I probably won't remember the vocab words than I needed for that psychology test. If someone gives me a refresher, just like a

> problem and a general guideline of what to do for a statics or a math problem, I feel like I'll remember how to do those broad concepts. That sticks with me and I'll be able to use that later. (Greg, Interview 2)

When ensuring that he “understands” rather than just memorizing things, he utilizes multiple SRL themes: *reviewing records, organizing and transforming, rehearsing and memorizing*, and *self-evaluating*:

> To make sure you understand, you're going over the concepts, you’re doing practice problems, you’re not just memorizing things, learning things, um,…I like to write things down, usually what I'll do is I'll go through my notes and then I'll do a list of the concepts that I need to know, and then, um, a lot of times like for chemistry, what I’ll do is I'll write down the beginning and the after and then if I don't understand why it gets there, then I'll go back in my notes, but a study sheet, like a summary sheet really works well for me because I’m getting the broad concepts. If I understand those broad concepts, how it gets from A to B and then not on the study sheet but, then in my head I know why it gets there, it really helps me. (Greg, Interview 1)

For concept-heavy engineering-related courses, such as statics and some of his engineering courses, he primarily uses *organizing and transforming*, specifically to either condense the information or to change material into his own words. Greg considers chemistry an engineering course, as he views the material as related to his MSE major.

This can be seen in his description of how he learned about reactions in his chemistry course:

> There's a lot of reactions that we have to know, and there'll be a structure, and then an arrow with some letters on it and then a different structure, so you can memorize a goes to b and it looks like c but it's easier for me, I understand why it goes to c. So, which letters move where… Um, so Instead of just like memorizing what element comes off, and what element comes back on, I have to know which elements act a certain way, that will take that off and then put a different one on, because there's, once you know that then you can think of the general trends, I haven't seen this particular problem before but I know what usually happens, and I can apply that, those concepts, and that understanding of the material to figure out what's going to happen. (Greg, Interview 1)

Another example of his *organizing and transforming* SRL strategy use is Greg's custom summary sheets. For example, he adapted a formula sheet provided by the professor and changed it into a review sheet by reducing the information into the important concepts to study for an exam and writing material in his own words.

Greg also selects the main ideas out of his notes (*organizing and transforming*) while *reviewing records* by highlighting, and often rewording, key information and formulas. He also uses these main ideas to *self-evaluate* by additionally highlighting things he does not remember.

For content-heavy, “memorization” courses, Greg primarily utilizes *reviewing records,* such as reading the textbook and *rehearsing and memorizing* strategies, which he also uses for his concept-heavy classes but not as his primary strategy. Using these strategies helps him to remember the material and key words. For example, in Greg’s statics course he had 26 concepts over 26 handouts that were given to him in class. In organic chemistry, he read through a list of reactions to review from previous chemistry classes. Greg often reviews materials multiple times, a form of *rehearsing and memorizing*, as well. For all his courses, he uses *setting goals and planning, seeking information, seeking social assistance, self-evaluating*, and *self-monitoring and keeping records*.

SRL in All Courses

Greg defines studying as a process, which focuses on understanding and true learning. He believes that learning is more important than memorization and has a specific view on understanding concepts:

> Well the way you study varies between people, but study skills I think is being able to process what you learned in your classes, and have enough of that knowledge, not just memorizing what you learn, but not memorizing what was taught, but learning what was taught. So you actually understand the concepts instead of knowing the answers. So, knowing how to get there. Study skills is going to be actually reviewing material in a productive way so you do gain that understanding. (Greg, Interview 1)

For all his courses, Greg utilizes three main strategies: the "Star Method" (*self-evaluating, self-monitoring and record keeping,* and *planning and goal-setting),* time management, and help seeking.

For the Star Method, Greg "stars" things he does not understand or needs to look into while taking notes in class. Then, when he is reviewing later and for an exam, he remembers to glance over it while studying. He will look over more examples and try to figure out "exactly what's happening." Greg primarily uses this technique for math and chemistry, which are concept-heavy. He does not use it for psychology because he feels that starring something would just mean he had not memorized it properly, rather than a lack of true understanding. Since he marks things he believes he does not fully understand when using the Star Method, he is metacognitively evaluating his understanding of material (*self-evaluating*). Greg also uses the Star Method to keep track of information he does not understand (*self- monitoring and keeping records*) and to make plans to review anything that is marked during his study time (*planning and goal-setting*). Greg is careful to plan how much time to allocate to different courses and concepts, so his Star Method feeds into his use of *planning and goal-setting* for all his courses.

Greg uses his time management, or *setting goals and planning* strategies, for all his courses, regardless if he views it as an "understanding" or "memorization" course. He uses these strategies in order to reduce stress and to reach his goal of "do well" in his courses. He reduces stress by avoiding procrastination and planning, as he described,

> Time management, given your load of work and the things that you have to do, pacing yourself out correctly so that you have time to do those things, that you finish them and that you finish that well. If you don't manage your time and you give yourself an hour for this homework assignment and it usually takes 2 hours, you might have to rush through it and not do as good of a job as you normally do. Then just based on how much stuff you have, planning it out so that you'll be able to finish everything. (Greg, Interview 1)

Greg realizes starting early and planning ahead helps him to keep up material, not get behind, succeed in his courses, and learn material. He feels that "spacing things out... you learn a little bit better." Greg believes that cramming causes additional stress and leads to subpar learning. Greg uses *planning and goal-setting* specifically for his engineering coursework as he is motivated by his high endogenous PI for this material:

> …engineering study skill… I use time management fairly well. Last night I had a big project due, at like 11:30 tonight, so I sat down, I was like I know it's due tomorrow but tomorrow is going to Friday and I'm not going to want to do it, so I just sat down and figured out what was wrong with the project, I figured out how to fix it, sat down for like four hours and just figured it out. (Greg, Interview 1)

Greg heavily uses *planning and goal-setting* by keeping sticky notes for tasks and allocating study time to different courses and concepts. Related to his *planning and goal-setting* strategies, Greg utilizes *giving self-consequences*: “A small break sometimes helps split that up and makes the goals for that day seem manageable.”

Greg uses help seeking strategies and personally uses *seeking information* more than *seeking social assistance*, since he prefers working alone. "I like to just sit down and figure out what I don't know and work on that instead of figuring out what other people don't know." Greg does not use his professors as resources, but he will utilize a tutor as a last resort: “The [tutor] was like, If I was like, if I didn't completely understand what I was doing, I reached out for a little bit of help from someone who could explain it.” Greg will typically use Google, thereby *seeking information;* however, he will use his roommate, who takes similar courses, as a resource if Greg feels working with his roommate will be faster to figure out the problem than by struggling on his own. Greg does realize that it may be better to ask someone for assistance than Google because the person will understand the problem and material better, while the internet will not have the exact thing he is looking for. With a person, Greg realizes the question can be reframed and the discussion can be more direct and relevant. If the person does not understand all of the coursework, s/he may be able to "steer you in a better direction." However, Greg uses the internet as it is easily accessible and is guaranteed to have related answers.

Other general strategies Greg uses for all his classes are *self-evaluating* and *self-monitoring and keeping records*. When self-evaluating, Greg checks answers on homework and practice exams, reflects on the success of his studying and changes his failed habits, checks returned class assignments, and ensures he knows material well enough to utilize it in future classes. Due to his motivation, which is increased by his plans and goals, he uses *self-monitoring and keeping records* and *structuring the learning* *environment* by going to class and taking notes. He also limitedly attempts to limit distractions while studying (*structuring the learning environment*) by putting his cell phone just out of reach.

SRL in a major-required MSE Course

Greg's FTP characteristics appears to have an impact on his self-regulated study strategies in his MSE course during the fall semester. Greg clustered as a Sugar Cone during the analysis of the MAE survey fall responses, with composite survey scores were high for F (5.75 out of 7), high for PI (7 out of 7), and medium to high for FoP (4.5 out of 7). His endogenous PI, possibly related to his MSE major and reflection on a major-required MSE course, is seen in his strong use of SRL strategies when studying for his first exam. Additionally, Greg's high scores may have impacted his strong use of goal-setting, which is one of his strongest strategies when studying for his first exam, but decreased in priority by his third exam.

When studying for Exam 1, Greg used seven of the ten SRL themes. Greg *structured* his study environment by attending class every day and taking practice exams just like a real test. He utilized *planning and goal-setting* to stay on top of course work and attend class every day. A strategic goal Greg set was for reading, "I would look through the chapter at the beginning of each module to see how many pages it was; from there I split up those pages usually into three sections and would read one every few days until I was done." Additionally, Greg *self-evaluated* by rereading the book if text was confusing, testing himself with questions and checking the answer key, and checking practice exam answers and ensuring he understood things he missed. Greg utilized *reviewing records* and *rehearsing and memorizing* strategies together when studying for his first exam; he reread his book, reviewed practices exams after completing them, reread notes from class, and reviewed old exams that his professor suggested. Greg heavily utilized *organizing and transforming* (writing notes from the book, creating a summary sheet) and described his primary strategy, or one of his "most helpful resources":

> I printed out the equation sheet so that I could use it like a summary sheet. The things that I had forgotten that I wanted to go back and look at a few more times I took note of on the back while on the front I defined all of the equations, the variables within those equations, how/when/why those equations are used, and also wrote out any derivations of the formulas that I would need to know. (Greg, Journal 1)

Greg also sought out information via a test bank based on his professor's suggestion; several of the strategies that Greg utilized for Exam 1 were suggested by his professor. This is an example of the importance, especially early in the semester, of professors teaching students the expectations of a course and the best way to self-regulate to learn the material. Overall, Greg's strongest and most heavily utilized skills were *organizing and transforming,* a strategy utilized by other engineering students in Chapters 3 and 6, and *planning and goal-setting*. *Planning and goal-setting* may lend itself to his Sugar Cone status, as Greg has a high endogenous PI for the material in his MSE class. Thus, Greg is utilizing *planning and goal-setting* behaviors to regulate his studying for his Exam 1 in this course.

For Exam 2, Greg primarily stuck with the same strategies used for the first exam, because he thought they worked. His primary new strategy was the use of *self-monitoring and keeping records*; Greg took notes in class and kept “records” of what he needed to do and study to be successful on the exam (also *planning and goal-setting*- heavy use of time management techniques). Greg spent most of his time studying by *reviewing records* for the second exam, including looking at the old test from the previous semester that his professor had posted. He mentioned that several of his class periods had been online rather than in person and that he had to spend more time reviewing homework because, even though he had learned the material, he didn't have as many examples in class. He also reviewed online material, "numerical problems," worked out examples, and reread old practice tests. He showed his strong *self-evaluation* strategy use during this reworking of problems and by ensuring his understanding while studying:

> For example, I loosely made the goal that two days before the exam I would read through all of the notes that I had for since test one and write down the highlights of those notes, the things I did not remember, and all of the formulas. (Greg, Journal 2)

For Exam 3, Greg *self-evaluated* and decided his study skills from Exams 1 and 2 had been effective. However, Greg was the least organized for this exam and did not plan his studying as effectively. He said he learned less and felt less prepared. He was less motivated because of his lack of *planning and goal-setting*. Greg did successfully *seek information*: “When I was unsure of a concept, I would find where it was explained in the book and if that did not help I would look it up online” (Greg, Journal 3). Even though Greg studied less, he still utilized *rehearsing and memorizing* and *reviewing records*:

> I read the chapters and finished the homework on time, but this time I did not plan everything out as well and was not as cognizant of upcoming deadlines and due dates. Because of this, instead of completing a little bit each day to avoid becoming overwhelmed, I started the assignments the day before or the day they were due. I believe this lead to less knowledge being absorbed and less learned from the chapters. This was a fatal flaw on my part as it was also seen in preparing for the test. I waited too long to start studying for the test, so I was not able to go into as in depth of studying as I had hoped for. (Greg, Journal 3)

Connections: Relating Greg’s FTP and SRL strategy use

Greg has an overall high endogenous PI for his classes and education, and he can relate the importance of his schooling to his career.

> I think a lot of what I'm doing is relevant to the future, I’m minoring in psychology, and I think a lot of those classes aren't specifically related but I think at the very minimum, the concepts of what I'm getting from these classes are related, so…I'm in statics right now, I think that's pretty important. I'm in organic chemistry II, which I think that one is going to be a little bit more of the broad

> aspects you need to know that things react, but you might not need to know exactly how everything works, you just need to know that it will work so you need to have a take away from that as opposed knowing everything we learned. Differential equations, I'm not exactly sure if that's going to be used. There's been some application problems but I'm not sure quite how to apply those yet. [Solid Works-focused course] …it really depends on the company, I feel like either that's going to be like a lower level kind of thing, like the executive isn't going to be modeling the parts on Solids Works, but I think it's good to know it. It's definitely practical for everything that I can do, but I think it depends on the company if you're actually going to use that, which the teachers actually said, we'll do two days on something and like depending on the company you might not use this at all, or you might use this every day. I'm in metrics testing lab… and that's testing materials which I think is extremely practical, I feel like I will be using things from that lab specifically this summer because we worked with like testing metals in a bunch of ways, we tested fibers on something, but you can use that same test in a different machine and you'll get the same process for getting the results. So, I think that one's definitely important. (Greg, Interview 1)

While Greg is minoring in psychology, he feels this subject is more interesting than useful. Unlike his psychology courses, Greg feels all of his MSE courses, especially anything engineering-related, will be useful in his career, and at a "bare minimum", the general concepts from the courses will be important. He feels skills he is learning, along with general concepts, will be useful for his career choice. Greg believes he needs to have “takeaways” rather than memorize everything he learned. He knows that the further you move up in a company, the less you use the general concepts. However, he is open to working in research and manufacturing and feels that more concepts will be utilized in the research side. Both of these upper-level roles will cause him to use more of the “broader” concepts, and he feels the business and engineering sides become more intertwined the more and more one progresses.

Greg feels many current strategies, some self-regulated, will be important for his future as an engineer. Greg feels organization and time management (*planning and goal-setting*) are important for studying and in his career. Additionally, Greg believes work ethic (“hard working and studious”) is important. He feels studying things that are confusing is important (*self-evaluating*), and that students should fill in information they don’t understand (*organizing and transforming*) by speaking with a professor (*seeking social assistance*). Greg feels being personable is important for an engineer as "…being able to talk and interact with people I think is an important skill. Especially in engineering because they usually have those stereotyped as not being very good at that" (Greg, Interview 1). This trait can help in collaborating, explaining material, teaching others, leading a team, and advancing in a company. Greg feels this one is important in his personal life and will help in building a family as well as he will have to “talk to girls” (Greg, Interview 1).

Greg feels his education is important to his career and he must graduate to have his career. Also, he feels this university in particular will assist in a strong career, because they have a career center and other networking resources. In addition to the material and concepts in his classes, Greg feels he is learning essential skills that are important for his profession from his university, such as being personable, working hard, working well, and paying close attention to detail. He doesn't think the coursework and learning concepts is enough and thinks if he hadn't gained skills, such as time management and communication, during his undergraduate degree, he'd "get fired pretty fast."

Greg utilizes similar strategies for engineering and non-engineering coursework but considers the material and strategies different, as discussed in the *General SRL* section. His choice of strategies appears to not only be related to the type of material in the course and whether he views it as understanding or memorizing, but also related to whether he holds a primarily endogenous or exogenous PI for the material in the course. His motivation for learning the material differs. For engineering, Greg says he "[learns] how to do the problem, instead of just learning what the answer is." While Greg works practice problems (*rehearsing and memorizing*) for most of his classes, his motivation for those problems differs between engineering and non-engineering. For engineering, he'll think through or write down the steps. He still uses *planning and goal-setting* but Greg utilizes more *rehearsing and memorizing* and *reviewing records* strategies for non-engineering courses, such as reading the textbook at certain times for his psychology class. However, he does utilize *organizing and transforming* while reading the textbook as he attempts to summarize in his own words to ensure he truly understands the concepts (*self-evaluating*). Greg's PI for non-engineering courses are primarily exogenous, as he sees less application for the concepts and does not see connection between material. Greg says he knows in all of his courses that he learned the material and used his study skills effectively if it reflects in his tests and quiz grades and if he gets asked about the material later and still understands the principles.

Greg’s endogenous PI emerges in his view that "understanding” is more important than “memorizing” as a study skill for his engineering courses:

> Beneficial to my education, definitely the understanding one, because even after you get the grade back for that class, or that test, you might have to use that information in the next class, you don't understand it in the intro class, you’re not going to understand it in the complex class. Everything is starting to stack. So you really have to have the base knowledge before you can build on it.

He learns the material “so that I can do well. And actually learn the information, without these study skills, without actually like understanding the problems, I know I’m not going to do well on the test, do well in the class, that's important to me to actually learn, what's going on in the classes instead of just getting a good grade.”

Greg sees a direct connection between studying in the present and his future career goals. He realizes he will not be able to accomplish his career goals, such as his DFCG, without studying. He studies to reach his goal of obtaining a decent GPA and to obtain related experiences such as his internship. He believes that the more he studies and self-regulates, the more he will be able to reach his goals:

> I feel like my goals are based on what grades I get in the class, but how I do in the class depends on if I understand the material, and how I'll be able to do in future classes, so studying is going to give me the grades which is going to help me achieve the goals. (Greg, Interview 1)

Greg sees study skills as “work habits” (Greg, Interview 1) and something to learn to do to succeed in the workplace in the future. He describes his *planning and goal-setting* as a specific important skill for the future:

> Those time management skills, things like focusing, writing out what you need to do, that's not just writing out what homework assignments you need to do, it might be writing out what projects you need to get done in the job, so I think that completely relates… the study skills are not just study skills, they're work ethic and how you go about a problem if you’re given just a big project and a month deadline in your job, it's not good to procrastinate it, you got to split it into chunks and know when you have everything done by. (Greg, Interview 1)

The Creation of Greg’s Path of Distal Future Goal, Distal Future Career Goal, and Proximal Sub-goals

During interview 2, Greg was given a set of cards with goals written on them from his first interview. He first started ordering them by groupings of related goals, as seen in Figure 6.10. Then, when prompted by the interviewer, he moved the groupings into a timeline, as shown in Figure 6.10. After a timeline was created, Greg was asked about strategies he is using to work towards each goal, the importance of each goal to his future (and to which goal in the future), and the timeline for each goal.

When Greg first created his path, he developed subsets of his goals: "end goals," "start goals," "want goals," and "zero goals." "Want goals" are goals that Greg wants to complete while he's in school. Greg's "start goals" are the goals that he wants to achieve to reach his "end goals," which Greg considers to be his goals at the "very end." Overall, Greg feels "want goals" will lead to his "start goals." His final group, "zero goals," are goals "that aren't super important… while in school" but are more "end results" that help him achieve other goals. For example, Greg wants to obtain a co-op but realizes that this will mean that he will not graduate on time, so he is willing to not complete his goal of "Graduate on time" to achieve a more important goal.

Table 6.4: Greg's list of goals from his path, including the type of goal, as color-coded in Figure 6.10, and the strategies Greg uses to achieve each goal.

<table>
<tr><th>Type of Goal</th><th>Goal</th><th>Strategies Used</th></tr>
<tr><td>A</td><td>Have a career that will advance me in MSE career</td><td>• Relevant job experience
• Pick a relevant job (not settling)</td></tr>
<tr><td rowspan="3">End Goal</td><td>Be happy</td><td>• Do extra stuff
• Enjoy what I'm doing
• Have a family</td></tr>
<tr><td>Love what I'm doing</td><td>• Narrow interest in MSE
• Experience in field
• Find a job that you like the people you work with</td></tr>
<tr><td>Have a job I enjoy</td><td>• Narrow interest in MSE
• [Gain] experience in field
• Find a job that you like the people you work with</td></tr>
</table>

	Work in glasses and ceramics eventually	• Get a job after college in glasses and ceramics • If not, get work experience

	Get a job in glasses and ceramics immediately after graduation	• Getting experience
		  • Internships
		  • Co-ops
		• Career fairs to network

	Move into leadership in a MSE job	• Start a job after [graduation] • Good work ethic (not just resume) • Work with others • Get stuff done • More important work
	Have a family	• None • "Up in the air"
	Make a comfortable living	• Doing what I can to get a job • To get a leadership position • Advance in career
Start Goals	Do what I can to start those goals (co-op, internship, narrow interest)	• Keeping grades up • Going to career fairs • Networking

	Co-op in [the next spring]	• Work in career office
		• Improve resume
		  • Keep grades
		  • Doing stuff outside of class

	Get an internship in summer	None, as goal is completed
	Get research experience	• Studying • Doing well in class • Getting experience • Applying to REUs • Network with prof
	Get experience in the field	• Internships • Co-ops • Graduating • Get job
	Narrowing interest in MSE	• Internship • Experience • Take more [specialized] classes • Go to presentations • Go to opportunities

	Have a career that will advance me in understanding of MSE	• Relevant job experience • Be involved in company
	Have a career that will advance me in ceramics/glasses	• Help narrow down • Picking job experience for one or both • More exposure
Want Goals	Do well in each class	• Studying • Focus on studying • Study skills
	Doing extra stuff in school (more than studying)	• Finding things you like
	Do well in school	• Studying • Focus on studying • Study skills
	Keep grades up	• Studying • Focus on studying • Study skills
Zero Goals	Minor in psychology	• Study • Take class over classes • Take extra classes
	Graduate [and] on time	• Keep grades up

When asked to edit his goals into a timeline, he first began by placing his "want goals" leading to his "start goals," which he described as a *contingent path***.** For example, Greg believes "study," a strategy or sub-goal that was deleted, leads to "do well in school" and "keep grades up" which in turn supports "get experience in field." The color scheme/labels in Figure 6.10 show that the "start goals, and "want goals" fall within the first 6 years of Greg's timeline, and all of the "want goals" occur before graduation. Greg's "end goals" are not listed until over three years after graduation, with all but one occurring more than 8 years after graduation in the path. Greg's "zero goals" occur 3-years post-graduation or have been removed.

At the top of his timeline, Greg has “have a family” (end goal), “doing extra stuff in school” (want goal), and “do what I can to start those goals” (start goal), which he considers to be goals he should be pursuing and working towards all the time, and labels each a “continuous goal.” These are located along the top of all of the other cards, away from and above the timeline. Greg’s goal of “doing extra stuff in school” requires strategies including finding things he enjoys and actually doing them. “do what I can to start those goals” will support his other goals efforts, and he will have this goal until he retires. He describes one example of this goal in action: he attends career fairs and talks to others to find an internship.

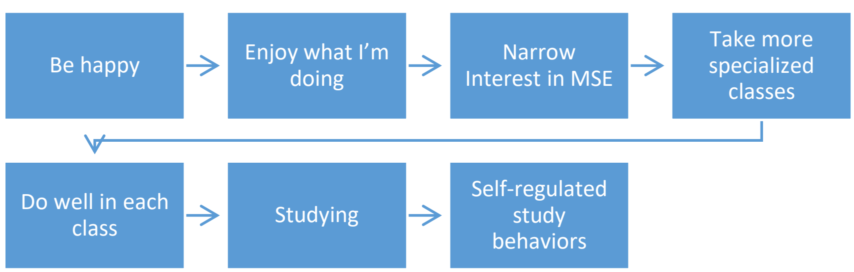
Altered goal cards: Greg’s timeline of goals begins with “get an internship [next summer],” which he considers a completed goal as he had already obtained an internship with a large steel company in the US, and ends with “be happy,” his DFG. For clarification of his timeline, Greg created sticky notes with times of around 1 year, 3 years, 6 years, 8 years, and 10 years after graduation. When Greg was asked to create a timeline of his goals, he removed them from the groupings and placed them into chronological order. After creating the timeline, Greg removed “focus on studying in school,” “study,” and “do well in class.” He added “narrowing interest in MSE,” which he felt was the same as “learn about the field,” and Greg decided to remove “learn about the field” from his original list of goals. Additionally, Greg felt that “get a job in glasses and ceramics after graduation” and “works in glasses and ceramics” were similar, but when he placed them into the timeline, he separated them by placing the first into the 3 years after graduation space and second in the 8 years’ space. Finally, the goal of “study” was deleted from the path as Greg feels that studying leads to goals and is a strategy, rather than serving as a goal itself. Additionally, when asked about editing any goals to ensure accuracy, Greg removed “focus on studying in school” and replaced it with “doing extra stuff in school.” Greg said the reasoning was, “I do want studying to be part of the reason I'm here, but I don't want that to be my main goal I guess. I want to further my interests and actually do things that I like, maybe like extracurriculars and things like that.”

Strategies for completing the proximal sub-goals in Greg’s path

When Greg was asked about his “strategies” for each goal/card/step, he looked at other cards as reference. The strategies that were written were primarily other goal cards. For example, strategies for “get experience in the field” (start goal), has a list of strategies including “internships, co-op, graduating, get job,” all of which are sub-goals on Greg’s timeline: “get an internship [next summer]” (start goal), “co-op [the next spring]” (start goal), “graduate on time” (zero goal), “get a job in glasses and ceramics after graduation” (end goal). Strategies, some self-regulated, that were identified by Greg are included in Table 6.4. Greg specifically mentions aspects of *seeking social assistance* via networking and *seeking information* by attending fairs and other informational events such as the Career Fair.

Table 6.5: A mapped sub-path created by a subset of Greg's goals and strategies, along with the created sub-path mapping from the goal "Be happy" to the final strategy "Study."

Goal	Greg's Strategies to Reach that Goal
Be happy	• Do extra stuff • Enjoy what I'm doing • Have a family
Love what I'm doing	• Narrow interest in MSE • [Gain] experience in field • Find a job that you like the people you work with
Narrowing interest in MSE	• Internship • Experience • Take more [specialized] classes • Go to presentations • Go to opportunities
Do well in each class	• Studying • Focus on studying • Study skills



Greg's path of goals was motivationally developed due to his DFG "Be happy." Two of the strategies Greg listed on his "be happy" goal card were "continuous goals": "do extra stuff" and "have a family." One was a direct sub-goal: "enjoy what I'm doing" which is equivalent to "love what I'm doing." By continuing through the strategies, sub-paths can be created by following a trail from goal to strategy and to the equivalent goal. For example, "be happy" may be traced to "study" by a sub-path, as shown in Table 6.5.

Greg specifically talked about the creation of two sets of paths of proximal sub-goals that were created due to short-term personally valued future goals, or DFGs, he had set. Specifically, he called graduating and getting experience in the field long-term goals. He explained that he has set short-term goals based on these longer-term goals, which is equivalent to creating proximal sub-goals to reach a DFG. In his description of goal-setting, Greg discussed a DFG of gaining experience in the field. He then sets up a set of proximal sub-goals to reach that DFG. This path can be seen in Figure 6.10 as Greg has secured an internship for the next summer and then he plans to continue to do well in school, set up a co-op, and finally graduate from undergraduate. Through this path of sub-goals, he is working to achieve this short-term DFCG of graduating and co-goal of gaining more experience in the field before he graduates. Additionally, Greg is currently using self-regulatory study habits to earn A's in his class and keep his grades up to reach his short-term DFCG of graduation. These paths of proximal goals are motivating for Greg and support his use of self-regulation. This flow can be seen in Table 6.5; similarly, sub-paths may be traced in Table 6.4.

Just as in the creation of these two paths, Greg has many sub-paths in his timeline, and the majority of these paths lead to present self-regulation. Greg listed some version of studying as a strategy for obtaining the majority of his "want goals" and "zero goals." Specifically, the five sub-goals that have a version of study ("studying," "study skills," and "focus on studying") as strategies are "keep grades up," "research experience," "do well in each class," "do well in school," and "minor in psychology" which are labeled in Figure 6.10. As discussed, Greg's study behaviors are included in the SRL themes from the SRLIS framework. He is a highly self-regulated studier, commonly utilizing *organizing and transforming behaviors* and *rehearsing and memorizing* for engineering, *reviewing records* and *self-monitoring and keeping records* for non-engineering, and *planning and goal-setting* for all of his courses. Thus, Greg's strategy of "Studying," "Focus on studying," and "Study skills" are equivalent to utilizing self-regulated study behaviors. Since a sub-path may be created starting with Greg's DFG to each of his "want goals" and "zero goals," Greg's DFG may be traced directly to his self-regulation in his courses.

Of significance from Figure 6.10 are several sub-paths. First, there is no sub-path that runs from Greg's DFG or DFCG to minor in psychology, showing that his paths are not contingent upon this sub-goal. While no sub-paths pass through Greg's goal of "Do well in school," Greg stated that doing well in school is more important than doing well in each class, and doing well in his classes will support his overall goal of doing well in school. Thus, doing well in each class could be considered an unlisted sub-goal or strategy for doing well in school.

As seen in Figure 6.10, there are several paths that start with "be happy" and run through "obtain a co-op" or another strategy related to the co-op experience. Since many of Greg's sub-paths are contingent on his ability to obtain a co-op, this is an important sub-goal within his timeline and a key piece to obtaining his DFCG and thus DFG. Greg feels the co-op experience is an important piece to entering the field and said "getting experience in the field, doing those internships, the co-ops that will let me get the foot in the door and those fields." He describes the importance of his co-op experience as one of the experiences he needs to get what he wants at the end:

> I want to be happy, love what I'm doing, have a job that I enjoy. The job that I enjoy would be working in ceramics and glasses, getting a job in ceramics and glasses after graduation, and then moving into a leadership position in my MSE job. Have a family and making a comfortable living. These are all at the very end what I want. These are things that I want to do to get there: co-oping, internship, research experience, experience in the field, narrowing my interests. This is doing what I can to start those goals is all of these things. (Greg, Interview 2)

Greg's Connectedness for Sub-goals in Path

Greg is clear about which goals he feels are important to obtaining his DFG of "Be happy." Additionally, Greg scored some goals as important to other personally valued future goals, which he considered sub-goals for being happy. Greg quantitatively appears to value his longer term goals more highly. The scores that Greg placed on the importance of each goal to reaching his DFG, or other specified future goal, is a measure of Connectedness and are included in Table 6.6.

Even though Greg feels a greater sense of connectedness between more distant PSGs and his DFG, he places a higher value on short-term goals, when not considering them in relation to his DFG. For example, Greg is focused on finding experiences in the present which will help him figure out what his MSE position may look like in the future. Greg's highest scored goals, those which he self-identified as between 8 and 10 on a 10-point scale, to his DFG of “be happy” are “work in glasses and ceramics eventually,” “make a comfortable living,” “do what I can to start those goals (co-op, internship, narrow interest),” “do well in school,” “keep grades up,” “have a family,” “doing extra stuff in school (more than studying),” and “have a job I enjoy.” A score of 10 likely signifies that the future goal is contingent upon the sub-goal. For example, Greg rated “get experience in the field” as 10 for importance of obtaining a “leadership job” in his field and thus he believes obtaining that leadership position is contingent on gaining experience. Greg also believes his goal of “be happy” is contingent upon “have a job I enjoy.”

Table 6.6 show two scores of particular interest. First, the only score of 0 shows the connection Greg feels between his goal of “Graduate on time” for his DFG. Greg realizes if he does a co-op he will not graduate on time. While the connection between not co-oping and graduating on time creates a contingent path, Greg is flexible with changing his graduation timeline to accommodate a co-op experience. Thus, Greg rated “graduate on time” as having a 0 value of importance towards his DFG. A second unusual score to consider is Greg’s “minor in psychology” goal. Similarly, Greg is planning a psychology minor because he enjoys it, and none of his future goals are contingent on this sub-goal. However, Greg views his minor goal as a 6.5 toward his goal of being happy, a 5 toward obtaining a leadership position, and a 6 towards having a family. Greg believes the information he learns in his psychology minor is likely to assist with his working with others and during projects on the job.

Table 6.6: The Connectedness score placed on the goal in the left column in reaching the goal in the top row during Greg's path creation in Interview 2.

Goal	Be happy	Additional goals and notes
Graduate on time	0	
Get research experience	3	5 if internship does not help determine future job
Co-op [the next spring]	5	
Get an internship in summer	6	
Minor in psychology	6.5	5, Leadership job; 6, Have a family
Get a job in glasses and ceramics immediately after graduation	7	7, Have a job I enjoy
Move into leadership in a MSE job	7	8, Make a comfortable living
Get experience in the field	7	10, Leadership job
Narrowing interest in MSE	7	8, Have a job I enjoy
Have a career that will advance me in understanding of MSE	7	
Have a career that will advance me in ceramics/glasses	7	
Do well in each class	7	
Have a career that will advance me in MSE career	7	
Work in glasses and ceramics eventually	8	
Make a comfortable living	8	
Do what I can to start those goals (co-op, internship, narrow interest)	8	
Do well in school	8	
Keep grades up	8	
Have a family	8.5	
Doing extra stuff in school (more than studying)	9	
Have a job I enjoy	10	7.5, Make a comfortable living

Relatedly, Greg pointed out additional goals he felt were significant in value towards another future goal. Greg feels that “get experience in the field” rates a 10 in importance in obtaining his goal of procuring a leadership position. Thus, Greg feels that to step into a leadership role in his work, he must first gain experience. This importance is also shown through the traced paths of strategies, as gaining experience is mentioned often as a strategy used to obtain goals. Additionally, it occurs regularly in sub-paths. Similarly, “move into leadership in an MSE job” holds an importance score of 8 in Greg obtaining “make a comfortable living,” so Greg feels that a leadership position will be instrumental in him earning money in his career. Greg also scored “narrowing interest in MSE” as an 8 and “get a job in glasses and ceramics immediately after graduation” as a 7 in importance toward having a position he enjoys. These high values show the connection that Greg feels towards his figuring out what specific position(s) he would like to hold in the field and how important it is to him to actually obtain a related position when he graduates.

FTP Characteristics and Connections to SRL Elicited from Greg’s Path

This section describes Greg’s FTP and SRL characteristics that contribute to the model in . Greg has views of how he wants his future to be; he would like to be happy, financially stable, married, and able to “provide” for a family. Greg also wants to have a practical, balanced life. These views of his possible self in the long-term has motivated his development of his DFG, his “biggest goal,” to be happy with all the things he is doing. Greg’s DFG and final goal on his path is “be happy” with more defined long-term goals, proximal sub-goals: “love what I’m doing,” “have a job I enjoy,” “make a comfortable living.” His DFG has motivated him to set sub-goals of having a family, getting a job, and making money, and he set these sub-goals by analyzing what would make him happy. Greg chose the MSE field because he enjoys it and thinks finding and working a job in this field will make him happy. For example, Greg is more concerned about happiness than making money, so he would have selected a different field than MSE if his main concern had been salary. Based on his DFG, Greg sets goals based on what he wants to do in the next few years. He says setting goals is different depending on the context. He set a goal of having an A in a class to reach a future goal, rather than to directly be happy, though the other goals will help him be happy. Greg selects his classes, besides those required, to expose himself to material to ensure he is on a path which will make him happy.

Greg's DFG motivated the creation of his DFCG. Additionally, Greg's DFCG supported the creation of his set of proximal sub-goals. These proximal sub-goals support strategy development, many of them self-regulated, to meet those sub-goals. Specifically, Greg has set sub-goals of "keep grades up" and "do well in school" which support his goal of "get experience in field" by allowing him the credentials to obtain related engineering opportunities, which would eventually support him "narrowing interest in MSE" and eventually obtain and engineering position in industry. Greg's grade goals support his exogenous PI for his coursework, which pushes Greg to utilize SRL strategies in his courses. Additionally, Greg's motivation to obtain an MSE position in glasses and ceramics in industry supports an endogenous PI for his engineering-related courses. below depicts Greg's FTP supporting the creation of a set of goals which eventually lead to his use of SRL behaviors in his courses.

Greg defines a key connection between FTP and SRL in his discussion of his path; a proximal sub-goal, "do well in school" shows this connection. Greg motivationally set a sub-goal of “do well in school” due to his DFG, DFCG, and following proximal sub-goals. To be happy, Greg must obtain his DFCG, which relies on him graduating and gaining experience, and thus on his sub-goal of “do well in school.” Greg describes a direct connection between the importance of his sub-goal “do well in school” and his current SRL strategy use: “keeping the grades up would be the same studying skills,” said Greg. He sees a direct connection between the importance of this sub-goal and his current SRL strategy use. To reach this goal, Greg is “Studying, focusing on studying in school, then all those study skills that I talked about, time management, organization, things like that.” Greg also reaches out for help when he has issues in a course to support the success of this goal. Relatedly, Greg’s goal of “do well in class,” inherently linked to his goal of “do well in school,” additionally supports his self-regulation in the present, as evidenced by Greg saying:

> I feel like my goals are based on what grades I get in the class, but how I do in the class depends on if I understand the material, and how I'll be able to do in future classes, so studying is going to give me the grades which is going to help me achieve the goals.

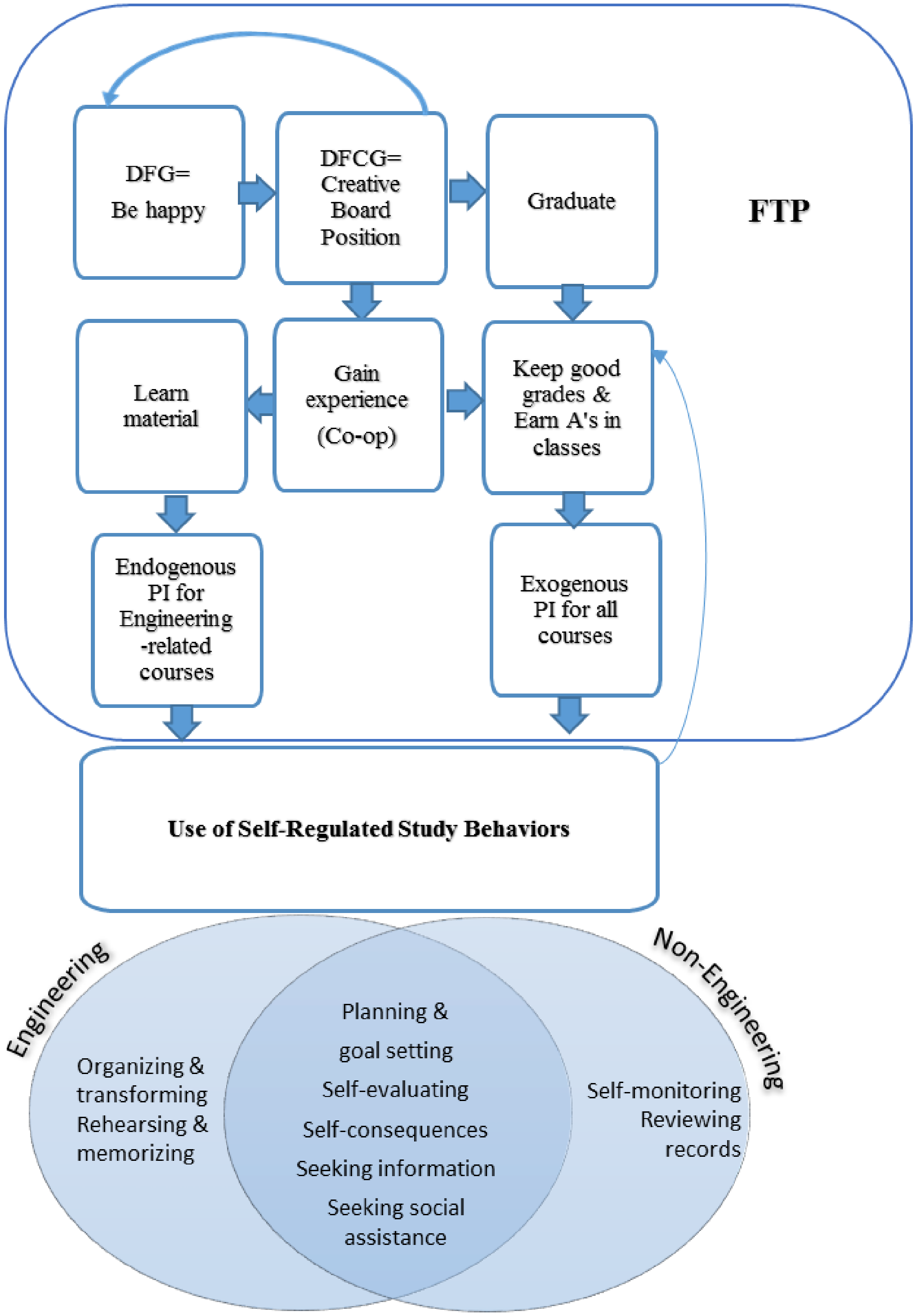


Figure 6.11: A model of the connection between Greg's FTP and his use of SRL strategies in the present.

Greg feels that doing well in each class is not as important as doing well overall in school. He feels that because of his goal of doing well, he focuses in classes on using study skills and studying. Greg believes success in school will provide him the opportunities he needs to move forward in his career path towards his DFCG.

Greg feels that because of his grade goals, he focuses in classes on using study skills and studying. Greg's goals of "do well in class" and "do well in school" can be directly traced to his goal of "be happy" such as in Table 6.5. Similarly, Greg has a goal of "keep grades up" between now and graduation. He relates this goal to his goal of doing well and says that the grade goal will help him with future goal. Greg sees a direct connection between using self-regulated study strategies in the present, meeting his grade goals, and the importance of his grades to achieving his DFCG, and thus his DFG.

Greg's path reaches over ten years into the future and his goals are well defined. He has a deep FTP with a long extension. This deep FTP directs Greg to have a strong connectedness between his present tasks to his future goals. Additionally, Greg places a high value on the majority of his goals, such as his goal of graduating. However, within his extended FTP, Greg is flexible and open to updating his DFCG to meet his DFG of being happy. If he realizes he is unsatisfied with any part of his life, he plans to update his DFCG, reflected by the arrow above Greg's DFCG in Figure 6.11.

Finally, Greg updates his SRL strategy use based on grade feedback he receives in his classes. He believes it is important to learn material for future use, as well as earn good grades to obtain experience to support his future goals; however, his feedback mechanism for self-evaluating and updating his SRL is through his grades. He does this in his engineering-related courses, such as statics, and he said

> Again, that depends on the class. Like statics, everything's online, so you don't have to show your work, you just put in an answer and it'll say if that's right or wrong. If it's wrong, you work it again, if it's right you know you went through the right steps to do it. For some other classes you might not get a grade back on the homework until the end. So if you get a bad grade back on the homework, I'll usually look over which problems I got wrong, and then sometimes the teacher will mark what I did to get it wrong. Hopefully I'll understand why it was wrong and what I'm supposed to do to get it right. (Greg, Interview 1)

Greg also updates his SRL for all of his courses by analyzing if his strategies were effective based on the grades he earned,

> I know I've used [my study strategies] effectively because you get to the tests, the quizzes, I can use that, um, that studying and it actually results in good grades, most of the time. And um, so that is how I know I used it effectively. Also, just even if a certain concept isn't on the test, I'll still know it and if someone shows it to me later, I'll still understand those principles so I know that I actually gained that knowledge. (Greg, Interview 1)

6.3.4 Cross Case Analysis

Future Time Perspectives

From these three participants, FTP appears to be context- and task-specific, fluid, and even volatile for engineering students. Additionally, many FTP characteristics are sensitive to external factors. Through the data collection methods, including journals, interviews, and survey data, a significant picture of student domain- and context-specific FTP was found and described. The quantitative data assisted in participant selection and assisted in triangulation of the richness and depth of the qualitative data.

In particular, the second interview, especially the card sort activity, allowed for a view of the students' DFGs, DFCGs, FTP extension and depth, possible selves, number of goals and their relationships, paths of proximal sub-goals, and other classic FTP characteristics. This interview revealed that all three participants are variations on the Sugar Cone FTP type and exposed a consistent issue with the current MAE survey. Additionally, each of the three cases reported an openness to change their DFCG based on whether they feel they are meeting their DFG through this current goal and path of proximal sub-goals. Finally, the interview illuminated the value that each participant placed on their sub-goals in reaching their current DFG.

Distal Future Goal and its relationship to the Distal Future Career Goal

In this study, all three participants described the same DFG; each of the participants felt that being happy was their most important goal and viewed themselves that way in the future. This happiness goal helped them create the rest of their set of goals. In turn, their DFG assisted in the selection of a DFCG, the individual's goal that helps the individual set up proximal sub-goals to reach. Cody has four DFGs with varying importance, dual-

DFCGs, and three convergent sub-paths leading from the present to his DFCGs; Barb holds a single DFG, single DFCG, and a clear path of proximal sub-goals; and Greg set one DFG, one semi-clear DFCG, and a single set of sub-goals which are assisting in clarifying his DFCG. While Barb and Greg both hold one DFCG, Cody has two DFCGs: his main goal of being on a creative board and his side-goal of consulting in humanitarian efforts. Both DFCGs relate to his career in renewable energy and influenced his adoption of three convergent paths of proximal sub-goals. Barb and Greg’s DFCGs influenced their adoption of a set of proximal sub-goals which lead from present self-regulation to their achievement of their DFCG. However, while Barb had a clear DFG and a clear path of PSGs, Greg had a less clear, though well-defined, DFCG and set a single set of sub-goals to assist in clarifying his DFCG. Likewise, Cody’s dual-DFCG was influential in the development of Cody’s convergent paths of proximal sub-goals. All three students set contingent and non-contingent goals which would assist them in their desired and possible futures.

Openness to Change in Career Path

Barb, Cody, and Greg place great importance on their “be happy” DFG, as evidence by their openness to changing their paths if what they are doing is not bringing them happiness. Cody actually has four DFGs but when ranking them, “be happy” is his most important. Cody recognizes his path may change if he realizes "that it's not fun” and is open to the possibility of several sub-paths in reaching his DFCGs; he believes his DFCGs will bring him happiness. Barb would change her goals if she figures out through some experience that she doesn't think she would enjoy being a pharmacist. She sees the value in having experiences now that will help her decide. Additionally, Barb realizes that even once she is in pharmacy school, she may realize she does not wish to pursue her DFCG, the pharmacist position, and she hopes it will not be too late at that point to change careers. Greg has determined that pursuing glasses and ceramics as a materials and science engineer in industry and transitioning into a future as a leader in the company and the field would bring him happiness. However, he is open to changing his DFCG and related sub-path of goals; he realizes he may decide to pursue another career while clarifying his DFCG through current internship and co-op. Greg said,

> Just like I said. I'd like to stay in the field I'm majoring in and just do what I actually like, so if 10 years down the road I find I want to do something else, I want to be able to move into something. I don't just have to go to work every day- I have to get to go to work every day. Enjoy my job. (Greg, Interview 1)

Like Greg, Cody is open to change but also realizes he is still learning about the field. He knows he wants to work in renewable energy but has three paths he has narrowed to: research, own company, and humanitarian. He is trying all of the things he can in the present to narrow down to one of these convergent paths which he believes will all lead him to reach his DFCG. Similarly, Greg is trying things to simply learn more because he does not know what potential paths exist within his field. Finally, Barb is extremely clear on her singular path and the sub-goals she needs to reach to obtain her DFCG, but she is open to other options to attain her DFG.

Variations of Sugar Cone FTP Type

The three case study participants are three variations on the Sugar Cone, with classic characteristics such as well-defined goals which reach 10+ years into the future, a matching ideal and realistic possible self, a strong sense of endogenous PI for career-relevant tasks and courses, and a strong sense of the impact of the future on the present. While Barb transitioned from Waffle Cone to Sugar Cone, her goals are currently the clearest, most well-defined and reach the deepest. She is motivated by her set of proximal sub-goals leading up to her DFCG (pharmacist). She self regulates in the courses she finds related to these sub-goals, by seeking good grades to get into pharmacy school and learning material in PCAT-relevant courses.

Greg has been a Sugar Cone student the entire year. However, his FTP is not very deep as he is unsure what the MSE field actually looks like. He sees the impact of his future goals on his present and is setting himself up for relevant experiences such as internships and a co-op to learn more about the field and clarify his goals. He utilizes self-regulated study strategies because of his high endogenous and exogenous PI for his courses due to his goals of learning material and earning good grades to achieve his proximal sub-goals or gaining experience and graduating.

Finally, Cody transitioned from Cake to Sugar Cone and has three convergent paths which lead to his DFCGs. Cody is either a sub-type of Sugar Cone Student, as he has a clear feedback loop between his future goals and his present, or he is changing between the two cones depending on the time in the semester. He is pursing things he enjoys and thus self-regulates in classes he finds relevant to academic and non-academic experiences he may potentially have. Overall, Barb, Greg, and Cody, are three Sugar Cone variants:

Barb’s is a clear, well-defined singular path; Greg’s is a semi-clear singular path; and Cody’s is three convergent sub-paths. All three students are pursuing a DFCG motivated by their DFG.

The MAE Survey and the FoP Construct

In the spring semester, all three case study participants scored relatively low in FoP (Greg, 2.5; Cody, 1; Barb 3) on the MAE survey, while showing a high FoP qualitatively. A low FoP generally maps a student quantitatively to a Waffle or Cake Cone. However, all three students qualitatively match a Sugar Cone student with FTP features such as well-defined career goals, a high PI for related material and courses, and a strong sense of an impact of the future on the present and vice versa. The discrepancy between the quantitative items and qualitative interview data can be indicative of a number of things including student causes, time concerns, and construct issues. As each of these students has a different career path in mind, their reflective course selection may have skewed the FoP scores. For example, Greg reflected on a CE course, which was outside his major and could have influenced how he felt his future impacted his present in that course. Additionally, after validity and reliability testing, only two items remained in the FoP construct, and as such, the items on the survey may not accurately measure the construct. Relatedly, the low number of items in the factor may have decreased the reliability of the measure. Also, students’ FTP is not a stable trait. The time in the semester could have affected the perception of the future on present actions for these students, and the time in the semester may have affected the FoP responses from the students. Finally, the number of potential goals or sub-paths in a students’ future may have impacted the MAE survey responses. For example, Cody's three convergent sub-paths may have affected his FoP survey responses. As such, there is still much more to learn about FTP in regards to the engineering domain and specific engineering-related tasks.

Connectedness: Far Future Goals Are Important to DFG

The case study students were asked to rank the value from 0 to 10 of each of the goals on their path in achieving their most important goal(s). Oddly, while the literature shows that students perceive goals to be less valuable with a longer time in between the present and the goal [150], all three students deemed goals further into the future, and closer in time to their DFG(s), to be more important for reaching their DFG(s). This may be related to the fact that people who have an extended FTP, which the case study participants have, feel that time is shorter between the present and future goals [150]. Also, this scoring was a measure of connectedness, rather than of value. For Barb, only one current goal of finishing the present semester was rated a 10 while the majority of her goals over 5+ years in the future held the same rating. Barb had the highest number of 10's, which supports the contingency of her sub-goals for reaching her DFCG and then her DFG. For Greg, his highest scoring goals (8+) were all in the far future: at least 8 years from the present. Most of Greg's current goals, such as interning, earning a minor, and getting research experience, scored below 7; these are relatively low scores as Greg's mean rating was 6.86 and mode was 7 when evaluating for his DFG. Greg also rated any of his sub-goals which he deemed important to his "Endgame goals," and, again, goals further into the future rated more highly. Finally, Cody's ratings ranged from 3 to 10 and he designated which of his DFGs each proximal sub-goal goal supported. His only 10 was “start a family,” which supported “be happy,” “make a difference,” and “be successful,” and most of his goals were rated 6 or 7. In general, all three case study participants rated their distal future goals higher than their more proximal sub-goals in their connection to a specified further distal future goal, and generally their DFG(s).

Self-Regulated Learning

The case study participants utilized some similar SRL strategies, but they differed in their definitions of study skill and engineering-related courses. These definitions, and their engineering disciplines, affected their use of strategies.

Definition Differences and the Importance of Grades

The three case study participants varied among their definition of “study skill,” how they believed SRL can be learned, how they actually learned their own study skills, and by the skills they used for engineering-related versus non-engineering courses. Details for the definition, avenue for learning, and strategies used are presented in acquired his current strategies through his tutoring position on campus, and through this job, he also learned about many resources on campus where students could learn how to

Table 6.7. Greg believes that study skills are work habits; Barb believes studying should lead to being able to teach material; and Cody sees a process in studying. All three include SRL strategies within their definition; for example, Greg describes *organizing and transforming* behavior and Cody’s definition involves *self-evaluating*. All three believed that study skills could be learned but mentioned different places or people could assist in this development. For Barb and Greg, the way they learned to study reflected the ways they suggested other students could potentially learn to study. Cody primarily

acquired his current strategies through his tutoring position on campus, and through this job, he also learned about many resources on campus where students could learn how to

Table 6.7: Definitions of study skill and suggested versus actual study strategies utilized by case study participants.

<table>
<tr><th rowspan="2">Participant</th><th rowspan="2">Definition of “study skill”</th><th colspan="2">Tools to learn study skills</th></tr>
<tr><th>Suggested</th><th>Actual</th></tr>
<tr><td>Barb</td><td>“To be able to comprehend all of the material and be able to explain it to another person… Just understanding well enough that you could teach it to someone else.” (Barb, Interview 1)</td><td colspan="2">Online
Trial and error</td></tr>
<tr><td>Cody</td><td>“If you have study skills, I think it means that you know A) how to get information, B) how to interpret information, and C) how to understand and commit that to a long-term memory, so not only, "Yeah, I can recall this. I recall that this, this equals this. I can understand why that is." (Cody, Interview 1)</td><td>Office hours
Professor
Tutoring or other resource on campus
Academic and non-academic counseling
Textbook</td><td>Tutoring position on campus</td></tr>
<tr><td>Greg</td><td>“Well the way you study varies between people, but study skills I think is being able to process what you learned in your classes, and have enough of that knowledge, not just memorizing what you learn, but not memorizing what was taught, but learning what was taught. So you actually understand the concepts instead of knowing the answers. So, knowing how to get there. Study skills is going to be actually reviewing material in a productive way so you do gain that understanding.” (Greg, Interview 1)</td><td colspan="2">Study skills workshops
Friends
Professor</td></tr>
</table>

job, he also learned about many resources on campus where students could learn how to study better. Interestingly, all three students adapted their strategies during the course of the year in response to exam scores and other graded feedback. For example, Barb self-regulated more for her third and final exams to obtain her goal grade in her MSE course, and Cody used exam grades as his primary goal for regulating his study behaviors.

Through grades, all three *self-evaluated* to see if they were meeting their grade goals but they also used the graded feedback as evidence that they had or had not learned the material. Then, they made changes to their study behaviors and self-regulated differently based on this grade feedback.

Table 6.8: The differences between case study participants' perceptions of engineering and non-engineering related courses and associated SRL strategies.

Participant	Engineering-related	Engineering versus non-engineering	SRL strategy use		
			Engineering	Non-Engineering	All
Barb	**Definition:** **"**Definitely making stuff, building whatever. Improving things that have already been made and things like that." (Barb, Interview 1) **Courses:** Science and science engineering	"Probably, the same. Just because I study the same for both of them." (Barb, Interview 1)	Rehearsing & memorizing Reviewing records Seeking social assistance (professors)		Planning & goal-setting Self-evaluating Organizing & transforming Seeking social assistance (peers) Structuring environment Seeking information
Cody	**Definition**: "I think it's anything where you do have to break down those projects, or you have to break things down into parts and then assign a task or create a model for it..." (Cody, Interview 1) **Courses**: Any course that may be used later in an engineering position. "I think any class that we take in our curriculum, like some kid is going	"I think specifically for engineering is going to be that ... being able to verbalize it. There's a lot of tough concepts and a lot of what we do is, like I said, breaking down a problem and assigning a model to it. I think if you can't understand it, if you can't walk through it and be able to break it down and assign it and assign different problems to it, then you're	Organizing & transforming Rehearsing & memorizing		Planning & goal-setting Self-evaluating Self-consequences Seeking information Seeking social assistance

	to be able to relate and make a better quality of life later on, so I consider it." (Cody, Interview 1)	not going to be successful in engineering." (Cody, Interview 1)			
Greg	**Definition**: "By engineering related I'm thinking more of working with what you're making… So, the engineering, um, [company] gave the example of like a car company would come to them and be like we need this. The engineers would figure out how to make that, what they need to make that, and how to make it cost effective, so engineer what they need to do…" (Greg, Interview 1) **Courses**: Related to MSE field, including chemistry	"It's a little different for the non-engineering classes. The engineering classes I feel like are more application, the psychology class is more read the text book and write down the key concepts and just memorize those concepts. The time management is still the same, but how I go about studying is different." (Greg, Interview 1)	Rehearsing & memorizing	Self-monitoring Reviewing records	Organizing & transforming Planning & goal-setting Self-evaluating Self-consequences Seeking information Seeking social assistance

Engineering- and Discipline-Specific SRL Strategies

The three case study students consider engineering SRL as distinct from non-engineering and use skills differently, as depicted in Table 6.8. Barb believes study skills are the same for engineering and non-engineering but she utilizes some strategies exclusively her engineering-related courses. She uses *rehearsing and memorizing* and *reviewing records* in her biology and BME courses, and she is also more likely to utilize her professor in these courses (*seeking social assistance*). Cody believes engineering courses require verbalizing and modeling for understanding, and he primarily uses *rehearsing and* *memorizing*, *organizing and transforming*, and *seeking social assistance* strategies. Similarly, Greg separates engineering-related courses (as with all his courses) into concept versus content-heavy courses; however, he believes engineering-related courses are primarily understanding-based courses and utilizes primarily *organizing and transforming* and *rehearsing and memorizing* to reinforce understanding. Greg also heavily utilizes help seeking strategies but leans towards *seeking information.*

The students reported different engineering-related strategies, depending on their engineering discipline. For engineering specifically, the students self-reported use of *rehearsing and memorizing* (by doing practice problems and exams), *seeking social assistance* (professor and peers), and *organizing and transforming* (making a summary sheet, connecting to other courses/info) strategies. Rehearsing and memorizing strategies were consistent across all three cases, which involved working practice problems and practice exams. However, Greg and Cody heavily utilized *organizing and transforming* strategies when figuring out how to complete ME and MSE-based problems. These strategies supported their understanding in the "how" and "why" of the problems and the individual steps in the process of problem-solving. However, Barb, a BME, utilized more *rehearsing and memorizing* and *reviewing records* strategies as she had more material to learn and memorize in her biology and science based BME classes. These primary engineering-related strategies differed across the three disciplines of the students.

All three students used a form of help seeking, and the differences in these strategies lie in the type (*seeking social assistance* versus *seeking information*) and the specific form of outreach when utilizing *seeking social assistance* (peer versus professor). Cody and Barb use peers as a key strategy for studying and both use study groups to *self-evaluate* their studying, as well as for *seeking social assistance*. Greg reported that he is more likely to utilize *seeking information* strategies, such as looking online, and will utilize peers when they are easily accessible or will know more information about a topic than the internet can provide. Greg's strategy use appears to be a personal, rather than context-based, decision. Cody also heavily uses *seeking information* strategies, and all three case study participants believe figuring out information through help seeking is essential as engineering majors. They feel these skills will be useful in the future and provide additional opportunities.

All three case study participants believe that using professors (one type of *seeking social assistance*) as networking and for future opportunities is imperative. While Greg lists networking as strategies to reach his future goals, he mentions professors as a key aspect of this networking, and during his second interview he said "Applying for the [undergraduate research experience] would help. Just talking to the professors more, I guess networking. Actually becoming familiar with who they are and what they're doing." Barb utilizes professors much more commonly in her major classes as she believes they are more likely to assist her in office hours if they know her, will be able to provide the best information, and may be important for later opportunities. Barb was able to obtain her study abroad through a BME professor, for example. Finally, Cody believes networking is an essential strategy to reach his goals overall, and he said professors are an important piece of that:

> I really like getting to know the professor. That was something in high school that I did, that I didn't really bring to college until this semester, and I really like that. I want to be able to get to the know the professors, make those connections…I know that making connections is extremely important in the professional realm, but also I just like meeting people and making friends. (Cody, Interview 2)

The reasons for the three participants' use of help seeking strategies match information-seeking theory as they perceive their professor(s) as knowledgeable in their field, accessible, a good source for information and future opportunities. The theory, in particular an information seeking model[219], shows that helping seeking is utilized when people believe the resource has 1) knowledge, 2) value, and 3) access. The accessibility piece is an issue for Greg and one reason he primarily uses seeking information strategies, but he uses a professor when it will be more valuable.

Connections between FTP and SRL

Feedback loop from SRL to Grades

All three students self-report a feedback loop between their SRL strategy use and the feedback they receive in their classes, specifically grades. While Greg wants to learn in his courses, he believes he can use grades as a feedback mechanism to know if he has learned and studied properly. During his first interview, he said, "I know I've used them effectively because you get to the tests, the quizzes, I can use that, um, that studying and it actually results in good grades, most of the time. And um, so that is how I know I used it effectively." Similarly, Cody believes his grades are extremely important and his final grades show himself and others what he has learned in his courses. He specifically said during his first interview, “My final grades…The grades a huge factor, and being able to accurately explain it to someone. Even if I didn't do great on a test, if I can look at a test and be like, ‘Oh, that was such a stupid mistake.’… There's a lot of people who really understand the material, but are awful test takers.” He describes self-evaluating and updating his strategies after unsuccessful test taking by evaluating what he did not understand; while the understanding is more important, the grade is how he realized he needed to evaluate and update his strategies. Finally, Barb similarly updates her strategy use after receiving graded feedback, which she considers a mechanism for knowing if her strategies were effective.

Path of Proximal Sub-goals and PI and SRL strategy use

The path of proximal sub-goals for each case study participant helped develop the endogenous and exogenous PI for their current tasks. Specifically, all three students set grade goals based on their goals of graduating and gaining experience. The grade goals were also related by the students’ motivation to intern, co-op, or gain some other relevant career experience as they saw a certain goal grade as necessary to attain those experiences. These grade goals, which were different for each case, motivated the students to utilize SRL strategies that they had found successful in all courses, both engineering- and non-engineering-related. Similarly, all three participants saw skills and content they learned in their engineering-related courses as valuable to their future goals: Barb due to her pharmacy interests, Greg due to his MSE industry goals, and Cody due to his renewables energy field career path. These career goals incited the creation of proximal sub-goals of gaining experience. These paths incited endogenous PI for career-and engineering-related courses due to a sub-goal of learning the material. These students then utilized self-regulated study strategies due to the endogenous PI for the coursework. Cody, Barb, and Greg all saw connections between their current tasks and their future goals. They were more motivated to self-regulate in the present provided that this self-regulation supports a future goal. The students self-regulated in courses due to the proximal sub-goals of graduation, gaining experience, and thus earning good grades and learning material. While each of the three had a different grade goal in mind, these grade goals assisted in supporting the students' self-regulatory habits in each of their classes. To learn material in courses relevant to their goal of obtaining experience, each of these participants set up SRL strategies to use in their major-, engineering-, and career-related courses. Overall, all three participants self-reported making direct connections between their endogenous and exogenous PI and their SRL strategy use. A strong, well-defined set of proximal sub-goals related to a distal future goal helped to motivate participants to utilize SRL strategies in their coursework.

Connections Model and Conclusions

Each case study participant's model has similarities that may be generalized into a final model, depicted in Figure 6.12. While the model is not generalizable overall, it is transferable to many engineering cases, in particular to students with Sugar Cone FTP type. Each participant described a DFG that motivated the creation of a DFCG. The DFCG motivated the creation of a path of proximal sub-goals that lead to the present. This DFCG is changeable based on continued progress towards the DFG. This flexibility and openness to change is shown in the feedback loop between the DFG and DFCG. If

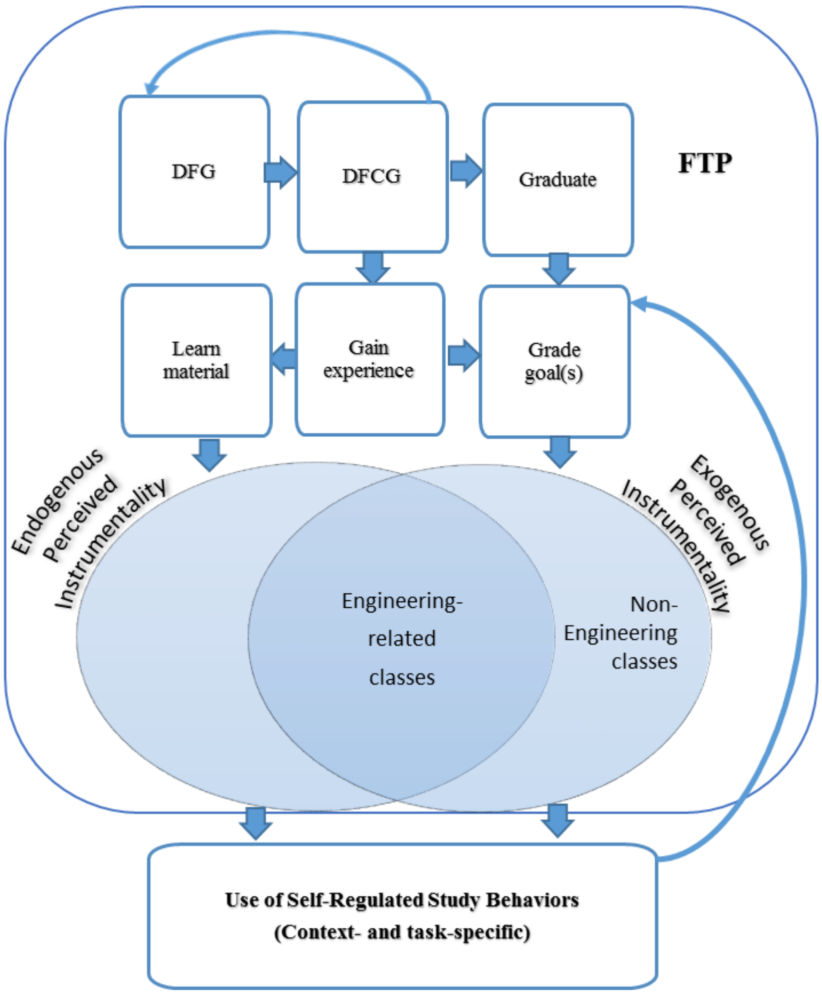


Figure 6.12: A model of the connection between Sugar Cone FTP type and use of SRL strategies in the present.

the DFCG changes, the path of proximal sub-goals motivationally created by the DFCG is updated, based on the DFG. In the model, sub-goals of Graduate and Gain experience are seen, which are contingent goals for these paths.

The Graduation goal motivates a grade goal. This grade goal is also supported by the Gain experience goal, as students must maintain a certain GPA to obtain internship, co-op, and other relevant experiences in their field, but this grade goal is dependent on the field. Gaining experience motivates the need for students to learn material. Then, endogenous PI is incited for engineering-related classes, which regulates the use of SRL strategies to learn material in those courses. For all classes (engineering and non-engineering), exogenous PI supports SRL strategy use in the present to maintain the grade goals. These strategies are context- and task-specific depending on the student's major, career choices, and if the course is engineering- or non-engineering-related. Finally, these strategies are updated based on the grades the students receive in their courses, which creates a feedback loop between the grade goal and SRL. The grade goal, rather than changing, motivates the student to self-evaluate and then update their SRL strategies as necessary. Overall, the DFG of a student assists in the selection of a DFCG which motivates the creation of a path of proximal sub-goals, some contingent and some non-contingent. The endogenous and exogenous PI for contingent sub-goals, and some non-contingent sub-goals, supports the SRL strategy use, and the student SRL strategies are updated based on the contingent grade goals.

CHAPTER SEVEN

7. Connections Between Future Time Perspective and Self-Regulated Learning

7.1 Overall Connections and Reflection on the Model for Sugar Cone FTP Participants

A generalized model depicted in Figure 6.12 shows the primary connections between future time perspective (FTP) and self-regulated learning (SRL) strategy use of students in a second-year engineering course with a singular, well-defined distal future career goal (DFCG) and contingent path. For each case study participant, the distal future goal (DFG), DFCG, set of proximal sub-goals (PSGs), perceived instrumentality (PI) of present tasks, and SRL strategy use were connected. Paths of personally valued future goals influenced the use of self-regulated study behaviors due to altered perceptions of instrumentality of current courses and tasks through the lens of these desired futures. Regardless of the specifics of an individual's path, the DFG, DFCG, and set of proximal sub-goals may be considered "purpose goals"[1] (p. 1). Purpose goals provide a basis for why the person is engaging in a task, a current goal that is being pursued, such as earning a good GPA to be accepted into pharmacy school. The strategies or approaches to complete a task, that the participants utilized related to SRL are target, or "how,"[1] (p. 1) goals. A target goal as defined by Harackiewicz and Sansone[2] refers to task-specific behaviors and the outcomes which a person would like to produce.

Specifically, for Sugar Cone FTP participants, a long extension was combined with the motivational creation of the DFG, DFCG, and PSGs. A feedback loop that existed between DFG and DFCG may alter the DFCG; with this update, the new set of PSGs would replace the current path, changing the list of courses in which a student may deem relevant. This path adjustment potentially affects endogenous PI and related SRL strategy use. For the participants, two contingent specific sub-goals of the DFCG, “Graduate” and “Gain experience,” further motivated sub-goals; both were related to and helped create the sub-goal of maintaining certain grades. Interpretation of tasks through students' desired futures influenced student approaches to self-regulation. This self-regulation shifted based on the context or task students were undertaking. The grade goal incited exogenous PI for all courses. While students believed that learning is essential to future goals, context- and task-specific SRL strategy use was updated based on graded feedback. When Barb felt that her self-regulated study behaviors had failed to help her achieve her grade goals, she “adapted some so the next time they do work.”

The generalized model demonstrated the main connection between FTP and SRL. FTP domain-specific traits supported student development of paths of personally valued future goals which altered their perceptions of instrumentality of current engineering and non-engineering tasks. The participants’ PI impacted the self-regulated study behaviors selected by the participants.

While the model developed for connections between FTP and SRL for Sugar Cone FTP participants honed in on specific aspects of domain-specific FTP, other key connections were featured in the participant data. Theoretical aspects of the Miller and Brickman model[3], namely proximal target goals, perceptions of instrumentality, past experiences, values, knowledge of possibilities, and self-concept of ability, are explored as indirectly contributing pieces to the connections between FTP and SRL. A final table is discussed showing summarized connections between career goal extension and task-specific self-regulation.

7.2 Proximal Target Goals and Their Importance in Self-Regulation

The Miller and Brickman model[3] depicts a system of personally valued future goals and their theoretical relationship to task engagement and self-regulation. In particular, a DFG supports the creation of a set of proximal sub-goals, leading to a more proximal target sub-goal. Previous research has shown that while personally valued distal future goals are motivational as people anticipate future outcomes[3–6], detailed target goals more fully support task engagement and achievement[4,7–9]. Additionally, the selection of these target goals is prompted by the value that the students place on certain PSGs and further future goal achievement[10]. Participants in this study were able to utilize a system of distal and proximal personally valued future goals combined with more proximal target goals designated due to PI of the present task to assist in self-regulatory study behaviors to achieve the current target goal.

To illustrate the importance of proximal target goals in self-regulation, an example from Barb’s case is used. Barb had a system of proximal sub-goals that lead from her DFG to her DFCG to more proximal sub-goals, such as graduate, obtain experience, and earn a 4.0 GPA. She narrated her path, “I'll use [engineering material] when I go to pharmacy school, so that will be right after I graduate. Then, potentially residency slash internship stuff. Then, having an official job. So I guess that's maybe 6 to 8 years…After that, probably do some kind of residency. Maybe specialize a little bit more. Then, hopefully, get a job within that specialty." Due to her system of PSGs, Barb had high endogenous PI for her engineering courses and exogenous PI for her engineering and non-engineering courses. She felt her engineering degree served as a "foundation for [her] to then use those skills to build on it and use them, but then also gain new ones." Additionally, Barb believed her future as a pharmacist was contingent on grade achievement as an undergraduate, and she specified, "I guess definitely grades and PCAT score rely or pharmacy school relies on those. The pre-reqs I take. Then residency relies on me getting into pharmacy school and completing that." Due to her perceptions of importance of grades and obtaining her future goals, Barb saw her spring semester finals week as important ("present task value" from the Miller and Brickman model), and she set a related proximal target goal of successfully finishing the semester by earning A's in each of her classes[3]. This target goal supported proximal task engagement and self-regulation by supporting her study habits while she prepared for final exams. Barb spent two weeks leading up to her finals week "really trying to figure out study plans for every class… Understanding the material, studying" (*planning and goal setting*). Due to Barb's career-related purpose goals, she was motivated to create more proximal target goals related to her self-regulation for finals week; the impact of proximal target goals on task-specific self-regulation is theorized by Miller and Brickman[1]. Moreover, Barb's SRL strategies supported her in reaching her contingent grade goal, furthering her goal achievement in her career-path, the depiction of her personally valued future goals and domain-specific FTP traits.

7.3 Relationship Between Future Goals, PI, Proximal Target Goals, and Self-Regulation

Previous work showed that proximal learning goals of students were instrumental in attaining personally valued future goals[11–14]. Similarly, in this study, participants' system of PSGs altered their perceptions of instrumentality of the task at hand. The participants then focused on more proximal target learning goals, such as Barb's focus on final exams due to her overarching grade goals, supporting task-specific self-regulation. When the participants worked towards achieving their grade goals, their PI was primarily exogenous for their non-career-related coursework. While some participants had set grades as particular goals in their path, the goal was not perceived as important toward a personally valued future goal but rather a "hurdle"[15] (p. 66) that held no future value[3]. For example, Greg said

> I think grades are very important because it shows that you understand the material, but if everyone got an A I think that, then it's up to you to decide if you earned that grade, if you actually understood everything enough to get that. So, you need grades because you can show grades. You cannot show understanding to an employer until you get the job. (Greg, Interview 1)

Thus, the incentive value stemmed from only the immediate grade outcome, and the participants self-regulated simply to achieve that immediate outcome. For example, in the introductory materials science and engineering (MSE) course, Cody studied to attain the minimum grade he felt was necessary to achieve his grade goals, as he felt the course material was less important to his future than other courses which also had exams that week. His self-regulation in his MSE course was low due to his low endogenous PI of the course material.

However, the learning material goals of each participant supported the endogenous PI of present engineering- and career-related coursework. Since the material was deemed as valuable in achieving personally valued future goals, such as their goals of gaining career-related experience and DFCGs, the students self-regulated to support immediate grade outcomes and to progress towards their future goals[3]. For example, Greg self-regulated in his introductory MSE course to earn a strong grade, to learn more about the major and his career, and to learn the material he would need in his future MSE position in industry.

Proximal target goals were the main source of motivation for task engagement and self-regulation in the present and served to motivate participants to study in their engineering and non-engineering courses. In each case, students' perceptions of instrumentality, both exogenous and endogenous, of their course materials and skill development were directly influenced by their career goals and caused them to create the more proximal target goals. These career paths were obtained through conceptions of their possible futures.

7.4 The Impact of Past Experiences on Knowledge, Values, Sub-Goaling, and Self-Regulation

The Miller and Brickman model shows the influence of past experiences (personal, social, academic, etc.) on the values and knowledge of possibilities that students have[3].

For the participants in this study, past experiences were seen to be influential on personal and career-focused values, the knowledge of career options, and on the creation of personally valued future goals including their DFG, DFCG, and PSGs.

Cody's past experiences guided his values, which were directly reflected in his DFGs (e.g., live sustainably) and his DFCG (e.g., creative board position with a focus on nuclear renewable energy), and he related his values to his personal-life and career-path,

> It goes with the renewables thing and it's a walk of life I'm passionate about, just being sustainable because obviously, it's pretty well known that this world isn't big enough for everybody on it and how we live. I think that's pretty important. Then I just think sustainable design is super cool, it's always high tech and very sleek and even if you don't care about sustainability, you should care about that, because that draws people in. Even if you're just an architect, it gives you people walking through the doors. (Cody, Interview 1)

He developed an interest in sustainability and making a difference in the world while growing up which guided his goal setting and influenced the skills he found important in engineering, such as communication which he described as, "I think a lot of what I do is communication based. Even internship. With nuclear engineering, we have to be able to kind of get information from whatever head, interpret it, explain it back." Cody used self-regulated study behaviors (*seeking social assistance*) to learn these skills to meet his future goals and support his values:

> It's like, "It's not the grades you make, it's the hands you shake." Anybody who I ask for help or anybody who has an understanding probably a lot of those people who are… able to communicate it to me have the same skills that are required to be successful, which is self-starting, being able to learn well, being able to communicate, having those people skills. These are people that eventually will be the contacts I need and then these are skills just going to continue on past that. (Cody, Interview 1)

Meanwhile, Greg's family and career-related experiences highlighted options in education, engineering, and MSE, and this knowledge assisted Greg is selecting a DFCG. Greg saw growing up the importance of pursuing college and how to set goals; he saw his family as influential in this: "I think my relatives and parents and the grownups around me, what they're doing, and how they got where they are, is giving me a general guideline for how I should set myself off." In high school, Greg learned through a summer camp that he was interested in MSE, and he finalized his decision after success in chemistry and his introductory MSE course. After learning more about the field, Greg established his DFCG of becoming a leader in a glasses and ceramics MSE position in industry, which further motivated his creation of PSGs. Greg's past experiences helped shape Greg's career-path, which has a direct influence on his self-regulation in his courses. He related his target goal of studying to his future goals which will further help him clarify his career path,

> I guess my main focus is just, studying in school so I'm actively focusing on doing well and doing what I can to start those goals. I got an internship so that I would be able to land, more experience, know more about the field that I'm in, and knowing earlier what I do or don't want to do. (Greg, Interview 1)

Due to these past experiences, the participants self-regulated according to their chosen career path which was directly influenced by their knowledge and values. This chosen career path was created as a tangible representation of participants' perceptions of the future and was directly influenced by values and knowledge of possibilities.

7.5 The Role of Self-Concept of Ability in Self-Regulation

Self-schemas, also self-concepts, are an important component of domain-specific FTP as they help students determine the viability of future goals[16–18]. In this study, participants each developed a schema of how they viewed engineering and engineering-related positions. This schema played into their view of themselves as engineers and whether they believed they had the abilities necessary to pursue positions as engineers or another engineering-related position. This schema also helped each of the three participants decide to pursue engineering as a degree. These types of schema have been shown to help build sets of personally valued future goals and are often considered early on in development of such paths[10,16,19,20]. For example, Greg realized as a child that he was strong in science and math and pursued engineering based on his conception that engineering involved math, science, and "working with what you're making." Specifically, he said,

> Ever since I was a kid, I liked math and science, I like math and I'm pretty good at it… I wasn't sure about the chemistry aspect part of it but freshmen year, the chemistry really clicked like it didn't do in high school. I actually started to like it in college, I liked the math, I knew that, but then the chemistry part kind of came together. (Greg, Interview 1)

Relatedly, the participants had a vision of how they believed they should study for engineering coursework in order to gain the engineering skills they felt were related to their future. Cody believed engineering to be "where you have to break down those projects, or you have to break things down into parts and then assign a task or create a model for it," and he selected engineering as a major as he saw it valuable for learning and for his future:

> I realize it's not just math and science and building blocks and stuff like that. It's a lot of- A lot of people will hire engineers regardless of the job, because it teaches critical thinking and being able to break down a problem into parts. I guess I'm pursuing it to continue those as well as it's actually applicable to what I want to do now, so now that I've chosen a career path that involves helping the environment indirectly, essentially, I think that engineering is the best major to go about that. (Cody, Interview 1)

Cody then self-regulated in a way that helped him build the modeling, verbalizing, and other skills which he considered engineering-related and necessary for his desired future, "My specific study skills of understanding it, talking through it, it gives me experience being able to either help other engineers be able to understand it or be able to help other people just don't grasp engineering or grasp the concept." The participants utilized their conceptions of engineering and personal abilities to determine their majors and other career goals. These goals then supported their self-regulated study behaviors in their engineering-related courses. This finding confirms the Miller and Brickman model[3], which identifies self-concept of ability as a key component in the creation of personally valued future goals. Conceptions of future selves and the creation of possible future goals are important parts of FTP that directly contribute to SRL.

7.6 SRL and the Connection to Participant Extension of Career Goals

Participants from the three FTP cone types utilized SRL in the present due to their domain-specific FTP, as summarized in Figure 7.1. Participants who used a high level of self-regulation prioritized the class and studying for related exams, adapted their strategies when they were not working, and used a variety of strategies to reach their goals[21]. Participants with a Cake Cone FTP type, with open views of the future, reportedly self-regulated in all of their courses as they found many skills essential to their future in their engineering and non-engineering courses[22]. Dana, motivated by her high endogenous PI and unfamiliarity with engineering, used SRL study strategies in all of her courses. She viewed learning and studying as an opportunity and planned to use what she was learning to narrow her focus in engineering. However, other students had ruled out certain career paths, and this affected their PI for respective courses. For example, Claire in Chapter 3 described low self-regulation for general education courses due to her focus on IE coursework and related skills.

Some participants with Waffle Cone FTP, such as Faye, used the goals in both conflicting paths as motivation to self-regulate in their courses, and others, such as Barb (fall semester) and Erin, used their short-term goals, rather than their divergent paths, as motivation to use SRL strategies. Faye classified her courses as IE, non-IE but still engineering, and general education. Due to her conflicting paths of continuing in industry or going back to school for a Ph.D. to pursue teaching, she self-regulated in all her courses; she found value in each type of class due to her two divergent paths. Barb, while conflicted between her avoided future as an anesthesiologist and her new unclear ideal future, still managed to regulate in her MSE course to meet her more proximal grade goals. Erin utilized her PSG of attending medical school, which is closer to the present than her divergent goals of pursuing OBGYN or family pediatrics, to push her self-regulation in the present due to her high endogenous PI.

For participants with Sugar Cone FTP, their DFGs and DFCGs motivated them to utilize SRL strategies in the present. Each of the three case study participants had set goals of being happy, which supported their creation of DFCGs. Then, each participant created a list of PSGs that created a path from the present to their DFCG and DFG. These students prioritized self-regulation in their engineering-related and career-related courses, which assisted in obtaining their proximal sub-goals. For example, Barb self-regulated in courses related to her BME degree and in PCAT-related courses. She identified these types of courses as priority based on a high endogenous PI, as the content was inherently essential to her future goals. Additionally, all three participants also set goals related to grades, which in turn motivated them to self-regulate in non-engineering courses due to a high exogenous PI.

		Level of Self-Regulation	
		Low	High
Extension of Career Goals	Short (Cake)	Courses unrelated to career paths that have not been ruled out	Majority of courses due to high overall PI
	Medium (Waffle)	Courses unrelated to either of two paths	Courses related to both paths and divergent DFCGs OR courses related to short-term goals before path diverges
	Long (Sugar)	Courses unrelated to career path	Prioritizes courses most relevant to career path

Figure 7.1: SRL utilization due to domain-specific FTP traits.

7.7 Connection Between SRL, Engineering Courses, and Future Goals

Within the K-12 context, Miller and Brickman described case study participants and the "instrumental connection between present tasks and future goals that give meaning and value to students' present learning"[10] (p. 130). Similarly, engineering undergraduate participants in this dissertation saw and described a direct connection between their SRL strategies, their engineering course work, and their future goals. For example, Amy, described in Chapter 3, explained how her self-regulated study strategies supported her grades, which helped her reach her future goals, "…studying gets me good grades which will get me into either a good grad school or a good job. They're pushing me along. So, I guess that's what's getting me towards my future goals is I'm building upon them. I'm using them as my tools to get somewhere." Other students described a connection in less specific terms but still deemed their SRL as useful and important for their future. Faye, in Chapter 5, said she would study the hardest for and utilize her SRL strategies in classes she would use later in either of her career paths as a professor or engineer: "I mean, looking at my IE classes, those are the ones I'm gonna use, so I like, definitely study the hardest with those because those are the ones like I would use either as an engineer or as professor or something." She also was very specific about how she decided if a class would be important to her future:

> I think it's like back to the type of class and like am I going to need this in the future, so like maybe my lit class down the road isn't going to help me set up this work space for like people building a light fixture, so ... it's going to affect like, "Okay, do I need to retain it, am I going to need it in the future?" Same with like my non-IE engineering classes, like okay, am I going to need this even if I don't take the FE? Trying to figure that out. Mostly just dedicating most of my energy and time and like study skills to those classes that I know I'm gonna use. (Faye)

For each participant in this study, the timeline constructed by the researcher based on interview data demonstrated connections between SRL and FTP by showing how participants' current strategy helped their achievement of future goals, including a DFCG and DFG.

Relatedly, PI affected the motivations of students to self-regulate in their courses. Students were internally or externally motivated and changed their SRL strategy use. Due to domain-general and domain-specific FTP, students set a path of goals, which led to short-term self-regulation in their courses. Students self-reported making direct connections between the usefulness of current tasks in terms of reaching future goals and their SRL strategy use. Students with more well-defined and contingent paths towards future goals reported a higher use of SRL strategies in courses they deemed relevant than students with ill-defined future goals. A strong, well-defined set of PSGs related to a DFG helped to motivate participants to utilize SRL strategies in their career-relevant coursework. This set of goals, contributing to a career path, was created by the study's case study participants and encompassed their possible views of the future and domain-specific FTP traits. Through this dissertation, we see that "…it is critical for students to develop personally valued future goals and a path of subgoals related to their futures in order for truly self-regulated learning to occur"[23] (p. 134).

8. Conclusions, Implications, and Future Work

8.1 Conclusions and Summary of Findings

This work describes the SRL strategy use and development by a group of industrial engineering (IE) students, a small number of IE and material science and engineering (MSE) student FTPs, an overview of selecting a cluster analysis technique, and three detailed case studies of mid-year engineering majors along with a cross case analysis. Through these studies, several aspects about engineering students and the way they view their tasks and goals within engineering were highlighted. Additionally, aspects of engineering student FTP, SRL strategy use, and the connections between their FTP and SRL were discovered.

8.1.1 Student Beliefs about Engineering

The mid-year MSE and IE participants' interviews showed that engineering students commonly believe engineering is problem solving or modeling. Multiple students included problem solving in their definitions or descriptions of engineering, engineering coursework, or what they saw as their future as an engineer. These types of definitions were common in all participants interviewed for this research. Whereas some students have clear definitions of what they believe engineering to be, other mid-year students may still be figuring out exactly what engineering actually is. In terms of connections between perceptions of engineering and students' FTP, unclear definitions of engineering were more common for Cake Cone participants, such as Anna from Chapter 5, but did also occur with Sugar Cone participants, such as Greg from Chapters 5 and 6, who are trying to figure out what positions look like in industry. Students were often unsure or still learning about what future engineering-related coursework and positions will look like. Their perceptions often did not match reality. For example, upper-level engineering courses, no matter the discipline, involve problem solving and higher order thinking, rather than simple memorization of material which these students have not yet experience.

Students commonly saw the connection between what they are learning in engineering courses and skills they will use within and beyond their career. In fact, most students listed the skills they felt they learned and were learning which will be relevant for their future in an engineering position. For example, Cody made clear that he believes what he is learning in engineering will be useful even in his personal life and said he will utilize engineering in almost everything he will do in his future. Other students, such as Anna, Barb, Erin, and Faye listed communication as an important skill they will learn in their engineering curriculum that will contribute to their future. Other skills, such as time management, team work, and being able to work on interdisciplinary teams were also commonly named.

8.1.2 Self-Regulated Learning

Engineering students consider SRL in their engineering courses differently than in their non-engineering courses, and use their SRL skills differently depending on context. Even when participants stated that they believed the strategies were the same for engineering and non-engineering courses, they articulated the different ways they use SRL strategies to study for these courses. For example, Barb stated that engineering and non-engineering study strategies are the same but then she explained that she is more likely to seek out help from her BME professors (*seeking social assistance*). This discrepancy in definition versus actual strategy use is likely due to the fact that students think “studying” is the same for all classes, but then, in actuality, the students utilize different study strategies depending on the content of the course.

SRL Strategies Used by Engineers

The MSE and IE participants show that engineering students are willing to learn new skills, especially if they find that their current skills are inefficient. Often, students reported adapting their SRL strategies after receiving a grade which they perceived as failure. Failure was often considered as not meeting their own goals. One student, Barb, described future anticipation of the need to update her SRL strategies due to fear of failure in her junior year.

Engineering students commonly stated that they use *organizing and transforming* strategies, such as creating a summary sheet or figuring out the steps of a problem, *rehearsing and memorizing* strategies, such as working multiple problems of the same type, and *seeking social assistance,* mainly from their peers in study groups. However, these strategies appeared to be discipline specific, as Barb, a BME, used practice problems but did not often use *organizing and transforming* as the other engineering majors, such as ME or IE, did. Cody, an ME, often used *rehearsing and memorizing* strategies. Students commonly used help seeking strategies, the most common of which was study groups, a type of *seeking social assistance*. The mid-year engineers used study groups to help figure out material they may not be able to solve themselves and to make their time studying more efficient and effective.

8.1.3 Future Time Perspective

Three types of FTP were observed in engineering students based on quantitative and qualitative analyses: Sugar, Waffle, and Cake Cone FTP type. These FTP types have been documented in the literature and were confirmed in this work. These types were seen quantitatively through cluster analysis of the FTP MAE survey items using composite scores and qualitatively through interview data.

Quantitatively, three homogenous groups were confirmed through cluster analysis of composite Perceptions of their Future in engineering (F), Perceived Instrumentality (PI), and perception of the effect of the Future on the Present (FoP) scores. These scores are seen in Table 8.1.

Table 8.1: The three FTP Cone Type scores based on cluster analysis of MAE survey responses

	Scores		
FTP Cone Type	**F**	**PI**	**FoP**
Sugar	High	High	High
Waffle	Lower than Sugar	Low	Lower than Sugar
Cake	Lower than Sugar	High	Low

The quantitative Sugar Cone FTP type qualitatively matches the type of student with a singular, well-defined contingent path of goals leading to a distal future career goal (DFCG) which was motivationally created by a distal future goal (DFG). Additionally, these students have a high endogenous PI for courses they feel are related to meeting their contingent path of goals. These students have a strong feedback loop in which their future goals have a strong influence on their choices in the present and their experiences in the present shape their future goals. The Waffle Cone FTP type scores match the qualitative student who holds two conflicting future views which a path of goals which diverge at an ideal future goal and a more realistic, though avoided, future goal. These divergent paths alter the students' PI of coursework in the present, thus impacting their present actions. For example, both paths may motivate student experiences in the present, but the feedback loop does not exist as for Sugar Cone students. Waffle Cone students' extensions truncate at their mismatched DFCGs. Finally, Cake Cone students feel they have infinite possibilities of what they may do in the future, matching the high F score. However, they may have ruled out certain careers, impacting their overall endogenous PI, which is quantitatively high but may not be as high as Sugar Cone students. These students are often still learning about their career options and thus are planning experiences in the present that will impact their future goals; however, they do not see the impact of their future goals, which mostly do not exist, on their present. Thus, a feedback loop does not exist for these students, and their FoP score is low.

FTP was confirmed to be a fluid construct, as seen in the literature[26], and confirmed by students' willingness to update their DFCG and by the change in FTP by two of the case study participants. In fact, students seek opportunities to update their FTP through experiences. All three case study participants were open to change, in particular if it helped them meet their DFG and DFCG. Cody even had new ideas and had changed his future goals during and between each interview. Barb had big life changes that made her change her goals and then used internships to figure out what she wants to do. Greg continued to set himself up to learn more to help him develop his future goals. While each of these three students are Sugar Cone types, their FTP changed between each interview; each interview was a snapshot of their FTP at that moment. FTP can change quickly and drastically depending on time, semester, course content, and experience.

8.1.4 Connections between FTP & SRL

This dissertation shows that the connection between FTP and SRL encompasses multiple facets, including concepts from education, sociology, and psychology theory, and the influence from these concepts may be direct or indirect. FTP traits and sub-goals directly influenced the self-regulated study behaviors of the case study participants; participants of all three FTP types showed direct connections between their future views and their study behaviors; and traits from the Miller and Brickman model[4] were shown to be an indirect influence on the connections.

The model developed in this dissertation around second-year engineering students with a well-developed FTP shows the direct connection between participants' DFG, DFCG, PSGs, PI, and SRL. Specifically, certain PSGs, such as obtaining certain grades or learning material, influenced the participants' PI of engineering and non-engineering coursework; these perceptions of instrumentality guided the adoption of certain self-regulated study behaviors, which were further updated based on a feedback loop between SRL and the participants' grade goals.

Furthermore, traits, such as past experiences, values, and knowledge of career options, related to but outside of FTP theory influenced the SRL of case study participants. Their past experiences impacted their knowledge of possible selves, including possible career and personal goals, and the values they hold. The knowledge of possibilities and the participants' values systems impacted the DFGs and DFCGs that the participants created and additionally influenced the SRL indirectly through these goals and directly as participants considered their values and knowledge of possibilities when making decisions in the present. Participants' view of their abilities influenced their decision to pursue engineering as a major, future career goals, and their self-regulation in their engineering and non-engineering courses. When considering their developed career paths, participants honed in on a target goal, which directly influenced task engagement and self-regulation.

Finally, a connection exists between FTP and SRL for the other two characterized FTP types. Waffle Cone FTP type participants, with conflicting ideal and realistic future views and a divergent set of goals, self-regulated either according to a PSG close to the present or highly self-regulated in courses related to both paths of goals. Additionally, Sugar Cone FTP type participants, with open views of the future, found most course material relevant to their future and self-regulated according to short-term PSGs.

8.2 Implications for Practice

8.2.1 Considerations for Engineering Curriculum

The work connecting motivation to SRL shows that the curricula for engineering programs should be tailored to meet the ebb and flow of the future goals of students.

While more work should be completed, especially qualitative work, to illustrate the FTPs of engineering students and how they develop from freshman to senior year, this project has shown that there are changes even within a single semester. The second year of an engineering program is typically the semester which students pick their particular discipline within engineering, whether that be biomedical, industrial, mechanical, etc. The first year of engineering programs often consist of a heavy load of science, mathematics, and general engineering courses to prepare the students for the future semesters and to assist in picking a specialty. However, students' FTPs the first year may be broad and allow for exploring of interests, with students holding all coursework, and often coursework not directly related to engineering, as important to their future. For example, a student with a Cake Cone FTP may see a Public Speaking or English course as instrumental as writing and presentations are important skills to develop as an engineer. Often, first-year students are unsure exactly what engineering actually is or what they could possibly be doing as an engineer, so all material may appear important to their future goals, which are often hazy at this point in time.

As students transition into their second year, non-engineering coursework and coursework not within the selected discipline may seem less important. The PI a student has towards a MSE course when a student has decided to enter the medical field with a biomedical engineering degree will have decreased. The PI in the same course of a student who knows s/he wants to be in MSE will remain high. At this point, some students will have picked a career path; some may have not; and those who have decided may still change with more experience. However, more students the second year likely have sugar-like FTPs, which shape a clear path of steps, motivating what material these students view as important and thus which courses on which to focus their self-regulation. These more focused students will no longer self-regulate as well in courses such as English or Public Speaking as they find them less instrumental to their future goals. While advisors, professors, and those in the career find presentation skills essential, second-year students now find the coursework that they deem directly relevant to their career as more important. Thus, a balance must be created which prepares first year students for their second year in engineering but also allows for non-engineering courses which are also essential, such as Public Speaking, when the students find the material relevant.

Several changes may assist in support student regulation in courses. First, universities should consider a shift that moves general education classes earlier in the curriculum. This would assist first year students, who are often open to multiple careers and are still learning about various disciplines, in learning general education skills. The curriculum, however, must strike a balance between preparing first-year students for their second year and stressing general education competencies. Since moving all non-engineering content to the first year is nearly impossible, other options should be considered. Faculty should work to employ tools which help support student motivation by presenting relevancy of material to multiple engineering disciplines. Activities may be used which cause students to reflect on how they view their future and goals and how the material and skills in the course may impact that future. Specific skills should be highlighted on the syllabus, during lessons, and throughout the semester, so that students will prioritize courses that they may otherwise deem nonessential.

More research must be done to quantitatively and qualitatively study the shifts in FTP, such as what typical percentage of students shift to a Sugar Cone over each year and if fall versus spring or other time points make a significant difference in student FTPs. However, it appears that there are shifts between the first and second year, and, in particular, that the second year is extremely developmental and causes students to shift into Sugar FTPs. Thus, a shift in the curriculum, focusing on balance general education courses, which are important to the future, at a time when the students view them as such, will be important in creating future engineers with the skills that are necessary to succeed in the field.

8.2.2 SRL Intervention

One key outcome from the FTP & SRL project is the development of a SRL-focused workshop, which can be used for future student learning, faculty development, in-class SRL strategy development, or to support SRL data collection. This workshop mapped SRL strategies onto an existing and heavily used strategy called the "Study Cycle." To thoroughly understand the SRL use of engineering students, an intervention was created which enhanced the "Study Cycle"[93] by introducing key pieces of SRL into a five step SRL process: previewing before class, engaging in class, reviewing after class, holding study sessions, and supplementing their learning with resources. Details about the intervention can be found in Chapter 2. The "Study Cycle" was selected for the basis of the intervention as it is commonly utilized in workshops through the university learning center and as a model for study strategies at several other engineering-focused institutions[94,96] and in previous literature[87]. Additionally, it was a strong base of commonly used study skills but was lacking in respect to SRL strategies. The "Study Cycle" was adapted to include all SRL themes from the SRLIS framework[63] into a workshop-style intervention to increase the fluency of the students in regards to SRL for data collection. While teaching SRL strategies as a separate course has been shown to improve grades[220] and motivation[221], students may struggle to utilize these skills within other contexts[221,222]. This singular workshop can be fit into a standard course as a class day and may be easily altered to fit within the course's specified context. By generalizing strategy use to particular engineering tasks, students may more easily begin adopting these strategies.

8.3 Implications for Research

8.3.1 MAE Survey FTP Section and Context Dependency

FTP was used as the focus for student motivation and viewed in connection with SRL strategy use of engineering students. This project discovered during the quantitative phase that the MAE survey items were heavily course dependent, and, in particular, that the PI items held a large weight in the survey. For the case study project, the composite scores of the case study students did not always match the qualitative FTP during the spring semester. A clear shift had occurred for two of the three students from fall to spring: Cody has shifted from Cake to Sugar Cone, and Barb shifted from Waffle to Sugar Cone. However, the quantitative scores of the MAE survey in spring did not match the current qualitative Cone characteristics. The mismatch in the PI score is likely due to the reflective course that was selected by the participants. In the future, using a consistent course would solidify the interpretation of the MAE survey results. Additionally, this issue should be kept in mind during analysis, as some students may be qualitatively Sugar but measure as another Cone type quantitatively based on the context in which the survey was taken. Another suggestion for analysis, especially for a cluster analysis, is to remove the context-based items. This would allow for a domain-specific view of FTP in the clusters and remedy some of the mismatching types.

In this work, the survey was completed in major-required courses, and in future work, the reflective course should be considered upon analysis. For the case study participants in Chapter 6, the MAE survey was distributed in an MSE course, which is a required, second-year course for many engineering majors at this institution. However, this course may not be viewed as instrumental by each discipline due to the nature of the content and its focus on materials. This content-focus may affect the quantitative FTP score on the MAE survey as the survey currently stands. However, a future project should work to develop more theoretical and domain-specific, rather than context-specific, FTP-type focused items, including depth of the FTP, time orientation of the FTP, etc. with less focus on the context. Domain-specific items, rather than context-specific, should perhaps be utilized. When context is removed, and thus the context-focused items such as the PI items, a clearer picture of the quantitative FTP may be realized for the students surveyed. Then, the quantitative FTP may have a clearer match with the qualitative FTP of a student out of a context of a course.

8.3.2 FTP and SRL Card Sort and Interview Protocol

An additional outcome of the work is a novel research method for the study of student FTP and how that FTP is connected to SRL for engineering students. In particular, during the second interview, a card sort method was used to elicit a list of the student's goals, the order of these goals, goals related to SRL, and other aspects of FTP. Students and/or the interviewer(s) wrote on index cards all goals mentioned by the student participant. The student was then instructed to organize the goals into a path. Additionally, the interview elicited strategies, often self-regulated, that the student used to obtain the goals and how important (on a scale of 1-10) the goal was to their distal future goal. These strategies, scores, and estimates of time to obtain the goals were written on the cards. The cards and path provided a rich data set for analysis of how student FTP type relates to strategies the student uses to reach goals. Additionally, the FTP codebook was expanded in relation to the FTP Cone types based on this work, as seen in Appendix S.

8.4 Limitations

While qualitative research provides a rich depth that may not be found in quantitative research, the work is not generalizable. The reader must utilize the data and results as presented to decide if the results are transferable to their population. For example, the MAE items were discipline-specific to engineering, and an adjusted survey would need to be used to analyze results of domain-specific FTP in another field. Similarly, domain-general FTP qualities would need to be added to the survey if a more domain-general lense were to be utilized.

With this research, the population was small and the majority of this project focused around three case studies. The three main case study participants in Chapter 6 were traditional second-year engineering majors selected from a required MSE course, which provides an extremely limited view of engineering students. While case studies are not inherently generalizable[215], aspects learned about FTP, SRL, and connections between the two may still be used and transferred to other contexts. Replication, through the use of three Sugar Cone engineering students, was used through the case study participant selection, which lends to transferability of the final model. However, all of the data collected in this dissertation was self-reported, and such accounts by students may be inaccurate, including pieces of SRL[223]. Thus, triangulation and theory were utilized to confirm results. The three case study students were different majors; while this provided a broader view and allowed for a comparison of SRL strategy use, this makes the results less generalizable. Case studies focus on a small sample of students. As seen, every student has different paths, which identify aspects of their FTP. However, every FTP-type has a large variation. More case studies or a phenomenography may support greater transferability of the FTP portion of this work.

Specifically, there is a cautionary tale in this work. This work seeks to view different students as they are, as they change, and as they maneuver through the engineering curriculum in hopes of seeing how they view their futures, what SRL strategies they utilize, and how those future views impact their SRL in their classes. The FTP cones and related work may be used to "type" students or to force them to grow into one FTP category. This work does not mean to limit students or dismiss opportunities. Rather, results should be used to aid greater understanding of how students may be learning, changing, growing, studying, and how to best support them in their learning. For example, students use different SRL strategies in different ways, with different intent, and for different reasons. However, context is extremely important, and rather than focusing on which strategies are used, students may be supported in trying all types of strategies until they find one that works.

8.5 Future work

While this work provided a mixed methods approach to seeing details about FTP, SRL, and connections between the two for engineering majors, the limitations, the scope of the research questions, and the results beckon future work.

Some studies would enhance the understanding of the FTP of engineering majors. A phenomenography of the FTP Cones in engineering would paint a clearer picture of the domain-specific FTP of engineering majors, allowing for clearer future studies. An updated version of the MAE survey, including more constructs such as time attitude, exogenous PI, and depth[48] would serve future work well by allowing for better quantitative assessment of student FTP. In particular, the FoP section needs to evaluated with additional items added based on focus groups or surveys of engineering students and literature. Up to this point, the MAE survey had been used to assessed four-year land-grant universities. This should be expanded to show the difference between engineering majors at each point in their career, within different courses, and in different college environments.

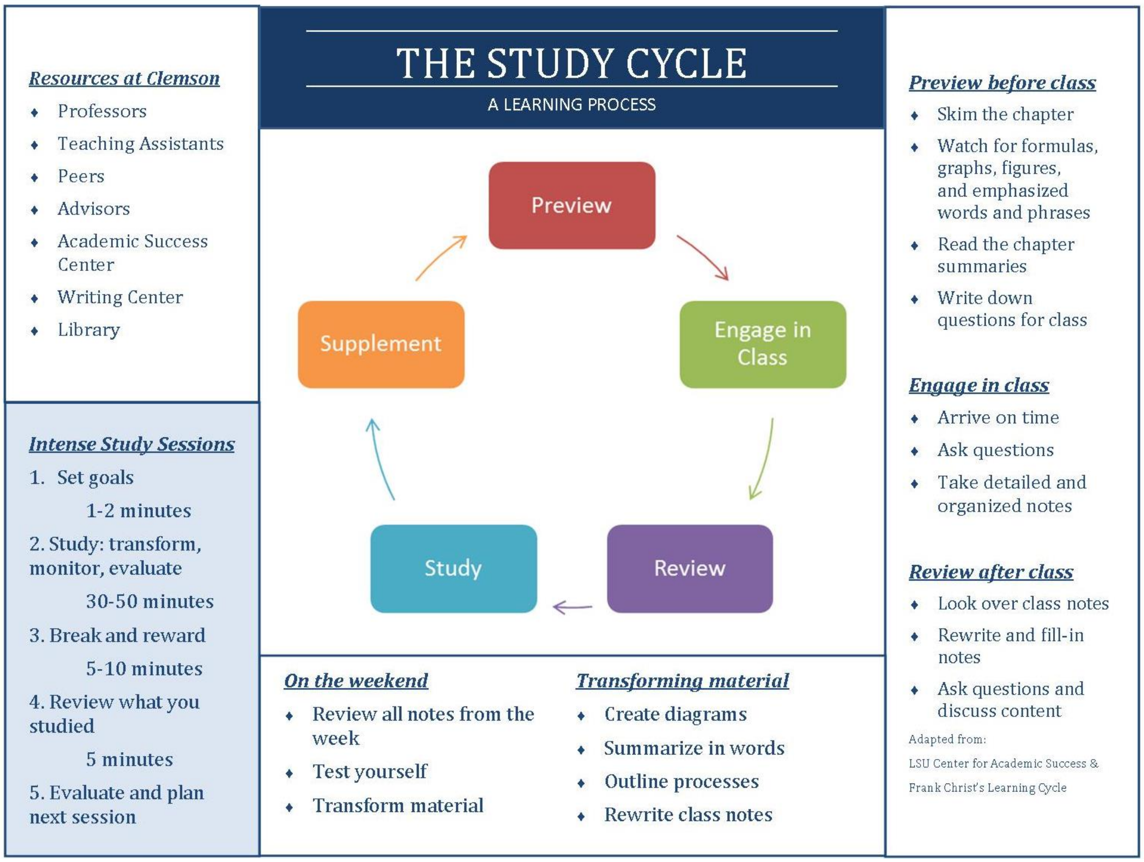
Some studies would enhance the knowledge about the use of engineering SRL strategies. A research to practice study involving the behaviors of professors which impact the SRL use of students would add value by showing how professors may improve the SRL strategy use of engineering students and elicit specific, context-based strategies. Similarly, a study to answer the research question "How do teachers view student FTPs and how FTP influences the classroom and SRL?" warrants future attention as it will add to the understanding of how teachers can better serve engineering students. Finally, a discourse analysis research project about the meaning of the word "study" for students and faculty and the difference between the two would add to the literature in engineering education.

Some studies would enhance the generalizability of this work. A similar study which selects multiple case study participants within each FTP type would allow for greater generalizability of a model showing the connections between FTP and SRL. A longitudinal study of one of these cases or a future case would add value to the literature by showing the change in FTP and its relationship to SRL strategy use. For example, Greg's change in FTP after his internship and then after his possible co-op experience may show changes in FTP or SRL. Finally, a quantitative study which creates and validates a survey assessing SRL for engineers and then utilizes those survey items along with the MAE survey items to assess the FTP and SRL connections would show a more generalizable picture.

APPENDICES

Appendix A: The Study Cycle, adapted from the "Learning Cycle"[93]

This appendix was originally Appendix A in Chasmar et al.[224], now modified and included as Chapter 2. This Figure depicts the Study Cycle Handout given to students during the intervention in the industrial engineering course during the fall.



Appendix B: Detailed description of the intervention (instructional module based on the Study Cycle)

This appendix was originally Appendix B in Chasmar et al.[224], now modified and included as Chapter 2.

At the beginning of the Study Cycle workshop, students were questioned about current study issues, such as finding strategies to study more efficiently. Bloom's Taxonomy [225] was mentioned to provide the students with a framework as to the level studying required for first year courses versus second-year, major courses. Throughout the presentation, students were asked to make note of their attention and anything distracting them during several "monitor your attention" slides.

The presentation stepped through the Study Cycle, starting with **Preview**. To reiterate the importance of repetition of material, athletics was utilized as an analogy through the presentation, with preview as the first "rep." The students completed a reading activity to highlight the importance of previewing. Specific strategies were explained to the students that can be used during previewing, such as scanning old notes, reviewing the syllabus, reading the chapter summaries, headings, and learning outcomes, and creating list of questions to be answered during class time.

During the **Engage** section, the presenter facilitated a two-part activity and discussion to stress the importance of being active, and not just listening, in class. Students sat back to back with the person facing the board as the direction-giver and the person facing the back of the classroom as the drawer. A picture was placed on the overhead and the direction-giver then explained to the drawer how to draw the picture while the drawer was only allowed to draw. The direction-giver then graded the drawer. A second picture was placed on the board and this time, the direction-giver and drawer were allowed to engage by asking and answering questions, pointing, and discussing, followed by another, often higher, grade. Both times, the drawer was not allowed to see the picture displayed on the board. A discussion about the difference between the two rounds was held to help students identify the second, more engaging turn as a successful classroom experience. After the discussion, students were taught about several different types of note taking, including the Cornell Note Taking method [226] and how to take notes on PowerPoints from the professor.

The **Review** section was initiated with a discussion of the "Curve of Forgetting" [227,228]. The discussion continued on the topics of editing, summarizing, reorganizing notes, writing questions, reflecting on notes and class discussions, and setting study plans during the review.

Goal setting and study time planning were discussed during the **Study** section, specifically mentioning "Intense Study Sessions" and "Weekend Review Sessions." Students completed an activity by discussing SMART (Specific, Measurable, Attainable, Realistic, and Time Bound)[229] goals and then were tasked with writing their own. The group discussed pros and cons of different study locations and environments and then the presenter supplied an example of a well-developed “Intense Study Session”: a well-structured study plan that identifies timing and content for goals, plans, breaks, review, evaluate and adapt.

Several methods of monitoring, such as setting performance goals, and evaluating, such as utilizing a post-test analysis, while studying were presented. The benefits of self-monitoring [230] and self-evaluating [231] while studying were discussed. Specifics about how to transform material were analyzed and students were given examples such as concept mapping, summarizing information in their own words, and predicting test questions. A weekly review, showing students how to study for an exam, was detailed. To help the students connect with the resources that are available on campus, they were asked to list as many resources as they could remember with a partner. A discussion of class, learning center, and other campus resources was held for the **Supplement** section**.**

Appendix C: Categories and codes used in qualitative data analysis

This appendix was originally Appendix C in Chasmar et al.[224], now modified and included as Chapter 2.

Category	Code
Environmental structures	• Avoid distractions • Change life habits (eating, sleeping, etc.) • Change study environment • Find a quiet place to study
Giving self-consequences	• Use reward system
Goal setting and planning	• Attend class more regularly • Manage time • Pace • Plan studying/study sessions • Review every day or periodically • Review several days before exam/ahead of time • Set study goals • Start homework early • Study the hardest material first • Take study breaks
Information seeking	• Check class resources (book, internet, videos, etc.) • Fill in notes • Review the syllabus • Use campus resources (i.e. library, test banks, etc.) • Use example methods from class to solve problems
Organization and transformation	• Create note (summary) sheet • Write summaries of class materials • Highlight key ideas • Keep organized (neat, Cornell, PowerPoint) notes • Reorganize notes • Take notes about book or readings • Transform material • Work real world problems
Rehearsing and memorizing	• Attempt problems before class • Make flashcards • Preview before class • Read before class • Repetition • Reread the book • Rewrite notes • Rework course problems • Work problems (from book, online, etc.) • Skim the textbook • Use the “study cycle”

	• Utilize memorization techniques • Write down equations
Reviewing records	• Discuss lecture content • Read reading assignments • Review class materials • Review every day or periodically • Review examples • Review homework • Review materials for test • Review notes from professor • Review old notes just before class • Review same day • Review worked problems in book
Seeking social assistance	• Ask a tutor • Ask advisor • Ask Academic Success Center or other campus resources (person) • Ask for help • Ask other students • Ask TA • Ask teacher • Group work
Self-evaluation	• Create problems • Evaluate after exam • Evaluate studying • Make sure to understand • Review at end of study session • Self-test
Keeping records and monitoring	• Ask questions in class • Engage in class • Listen during lecture • Manage attention • Self-monitor • Sit in front/ center of the classroom • Take notes • Write questions down

Appendix D: FTP Items from the MAE survey distributed in pilot study including factor of item utilized in the cluster analysis

This appendix was originally Appendix A in Chasmar et al.[40], now modified and included as Chapter 3.

FTP Factor	**Survey Item**
Perceived Instrumentality	I will use the information I learn in this course in the future.
Perceptions of the Future	I am unsure what my future career will be.
Future on Present	My future career determines what is important in this course.
Perceived Instrumentality	I will not use what I learn in this course.
Perceived Instrumentality	I will use the information I learn in my course in other classes I will take in the future.
Perceptions of the Future	My interest in a career in engineering outweighs any disadvantages I can think of.
Perceived Instrumentality	My course work is preparing me for my first job.
Future on Present	My future career influences what I learn in this course.
Perceived Instrumentality	What I learn in my engineering course will be important for my future occupational success.
Perceptions of the Future	I am considering switching majors.
Perceptions of the Future	I am confident about my choice of major.
Perceived Instrumentality	I do not connect my future career to what I am learning in this course.
Perceptions of the Future	Engineering is the most rewarding future career I can imagine for myself.
Perceptions of the Future	I am considering multiple careers.

Appendix E: FTP and SRL Interview 1 Protocol

This appendix was originally Appendix B in Chasmar et al. [40], now modified and included as Chapter 3.

Long Term Goals (FTP model) Conceptual Replication Study

What are your goals for the future?

- What are your personal goals for the future?
- What are your career goals for the future?
- Describe where you see yourself in 10 years?
- Can you think of anything that could make you change your goals?

What would you ideally like to be in the future?

- If you could pick one thing and it could happen, what would it be?
- If you could pick a professional goal to attain, what would it be?

What do you think you can be in the future?

- What are you actively striving for?
- What goals are you currently pursuing to reach this future?

What do you want to be in the future?

- In other words, what jobs, or careers do you know you do not want to pursue?

Perceived Instrumentality

Why are you pursuing an engineering degree?

- In what ways do you plan on using what you are learning in your current major as part of your day-to-day work?
- For how long after graduation do you plan on using what you are learning in your current major as part of your day-to-day work?
- How long do you plan on remaining in an engineering related profession after graduation?
- What do you consider an engineering-related profession?

What parts of your education do you see as relevant to your future?

- What skills are relevant to your ideal self (who you would ideally like to be)?
- What skills are relevant to who you think you could be?

How do you see your education playing into your career?

What skills do you view as important for your profession?

What kind of profession (If more than one profession mentioned)?

How did you develop these conceptions of your future?

<u>Present study skill use and perceptions</u>

Define study skill?

Do you use any study skills?

What are they?

Where and how do you use them?

Do you use different study skills in IE?

Why or why not?

What is an IE study skill?

Have you used any of these study skills while pursuing your IE degree?

If yes, please describe in what context and what you were doing.

Have you used IE study skills effectively?

If yes, describe a time you used IE study skills effectively?

What did you do?

Why did you use these skills?

What was the outcome?

What worked?

What didn't work?

How do you know if it didn't work?

How do you learn something in your IE classes?

How do you know you've learned it?

How would you tell another student to be successful in your IE classes?

What would you tell other students about what to do when they sit down to study/during study time?

Describe an IE study skill that would be beneficial to you in your IE education.

What makes these study skills beneficial?

Have you utilized any of these study skills while pursuing your IE degree? (may be a repeat)

If yes, please describe in what context and what it looked like.
If no, please describe where your ideal study skills could fit into your degree.

How do you remember your discipline?

How do you remember aspects of your classes? Topics?

Is it possible to learn IE study skills?

If yes, where do you learn study skills to be used in your IE classes?

Can you give me an example of where/how you used these skills?

Where or in what context do you use these skills (homework, projects, studying for test, etc.)?

What is your goal when you use IE study skills?
What if anything do you *personally* hope to get from using IE study skills?
Do you use study skills in your non-engineering classes?

Why do you use these skills?

Are these skills different than your engineering study skills?
If yes, where do you learn study skills for your non-engineering classes?
Are study skills different between non-engineering classes?

<u>Interconnection of Long- and Short-Term (Goal orientation)</u>

How do the IE study skills you use relate to your future goals?

In engineering courses

In co-op/intern

In research experiences

How do your future goals affect how you approach your IE study skill use?
Will using IE study strategies/skills help you get to where you want to be in the future?

Why?

How?

What do you define failure as?

Have you ever struggled to use IE study skills?

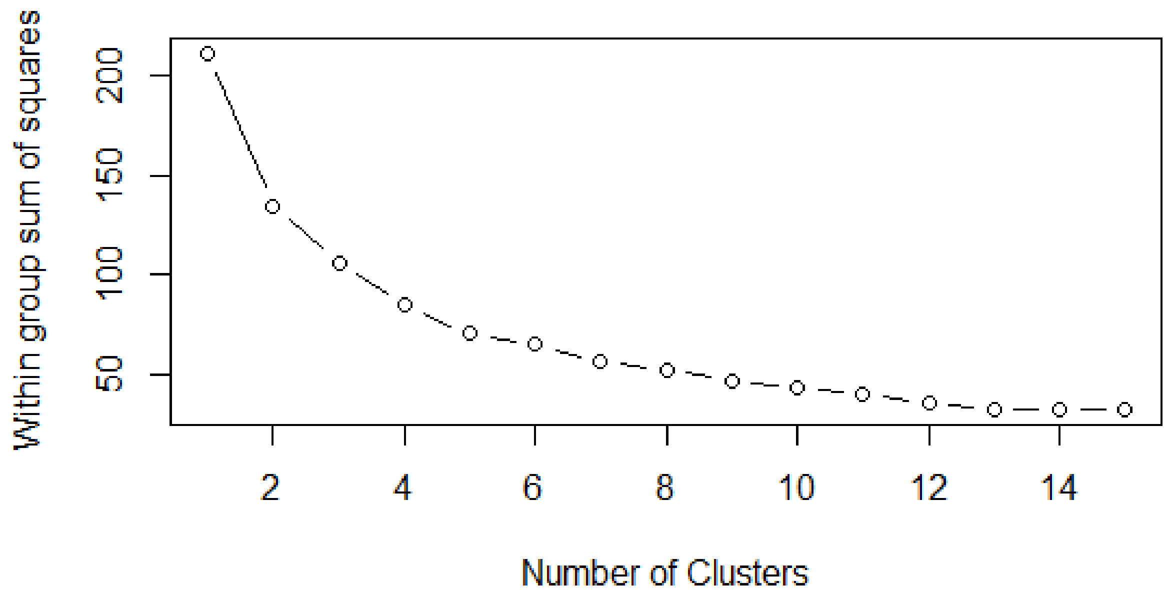
	If yes, what do you do when you struggle to use IE study skills?
How do you define success?	
What do you consider success in terms of using IE study skills?	
How important are grades?	
	If yes, why?

Demographics and How did you get here (past and future connection):

Which presentation did you view in [IE course]?	
	Study Cycle in person, Test Anxiety in person, or Test Anxiety online?
Did you change your study strategies after attending the workshop?	
How did you benefit from any changes?	
What level of engineering are you in?	
	How long have you been enrolled at [university]?

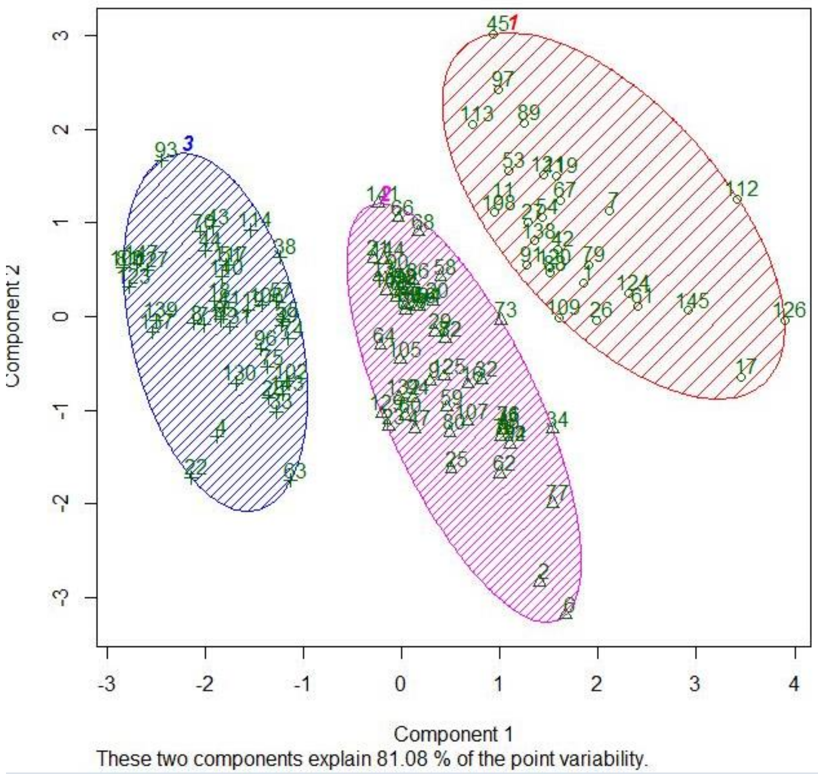
Appendix F: Plot of variance used to select the number of clusters for cluster analysis for IE student data through the MAE survey distribution in pilot study

This appendix was originally Appendix C in Chasmar et al. [40], now modified and included as Chapter 3.



Appendix G: Plot of three clusters for IE student data through the FTP section of the MAE survey distribution in pilot study

This appendix was originally Appendix D in Chasmar et al. [40], now modified and included as Chapter 3.



Appendix H: FTP Codebook for IE pilot interviews, including descriptions of FTP categories found in the literature and representative quotes from study participants.

This appendix was originally Appendix E in Chasmar et al. [40], now modified and included as Chapter 3.

Category	Code Name	Description	Example Quotes	Example Interview Prompt
Future	Future Career	The student describes attributes or characteristics of their future career.	"I just want to do all the operations. I like operations research. I enjoy efficiency." -Blake	"Where do you see yourself in 10 years?"
Future	Outcomes of Future Career	The student describes outcomes of their future career	"I wanted to be able to use my hands and my brain to make something that could benefit me or benefit the world." -Amy	"What are your career goals for the future?"
Future	Steps to Reach Future Goals	The student describes a series of steps or paths needed to reach a distant future goal.	"If I was going to go to grad school I would maybe want to get an MBA and become a manager." -Amy	"How long do you plan on remaining in said career?"
Future	Desired Future	The student describes what they do want to be in the future.	"Anything like system designs or process engineering." -Claire	"What do you want to be in the future?"
Future	Undesired Future	The student describes what they do not want to be in the future	"I don't really have any desire to teach. My mom's a professor right now... I'd rather just work for a company and work with products and systems than teach the material." -Claire	"Is there anything you do definitely don't want to do?"
Future	Realistic Future	The student describes what they can realistically do in the future.	"I like engineering, so if I find a nice job I will stick with it if I have some nice research or something." -Daisy	"What do you think you can be in the future?"
Future	Ideal Future	The student describes what they ideally want to do in the future.	"My dream before, I wanted to be a pharmacist, but I don't think I want to be that anymore and then I wanted to open a bakery [laugh] and now I don't really know." -Daisy	"What would you ideally like to be in the future?"
Future	Well-Defined Future	Having a defined future goal that one wants to attain. The goal should be clearly	"Realistically in the future…an eventual goal…COO, chief of operations." -Blake	"What are your goals for the future?"

		defined by the student. The sources of these future goals are coded separately.		
Future	Ill-Defined Future	The student describes a future goal using ambiguous terms. The goal is not clearly defined by the student. The sources of these future goals are coded separately.	"Just honestly, I would go wherever the breeze took me. I would want to take as many opportunities to try out interesting things, and hopefully 10 years down the road I would be in a job that I would like or I would know that I was good at." -Amy	"Describe where you see yourself in 10 years."
Future to Past/Present Connection	Future on Present	The student describes how their future goals are influencing what they do in the present.	"In high school I knew that I wanted to go into engineering just because it's a good field to go in. I've always heard that you get good jobs… so I came to college and I was like, "I'm going to be a chemical engineer." -Claire	"What skills do you consider relevant to your ideal self? Who you could be?"
Future to Past/Present Connection	Past/Present Actions Influence on Future	The student describes how what they do in the present or what they have influences what they will do in the future or what their future goals are.	"I'm an IE, so right now I am… I have an internship for the summer so I'm going to see if I like manufacturing, because that's usually what people think of IE's naturally." -Amy	"Why are you pursuing such a degree?"
Perceived Instrumentality	Perceived Instrumentality	The student describes how relevant they view certain tasks	"Some stuff we learn I can just apply to my life, and I can see how people are very difficult, and they could do it much easier." -Daisy	"How do you see your education playing a role in your career?
PAST	Past Experience and Perceptions	The student describes an experience that occurred in the past or a perception of the present or future that was formed in the past.	"'By sitting really angrily wasting a lot of time in the Marine Corps, by thinking about "Why is this so poorly done? What could be done better about this?"' -Blake	"What do you think you can be in the future?"

Appendix I: SRL Strategies utilized by each case study participant, including their FTP cluster

This appendix was originally Appendix F in Chasmar et al. [40], now modified and included as Chapter 3.

Participant	Cluster	SRL Category	Example Quote
Amy	1	Goal setting and planning	"Preparing ahead of time. Not cramming the night before. It's nice to hear that preached over and over because you finally start doing it."
		Keeping records and monitoring	"Effective note taking. Being… not writing down everything you hear but writing down the main points and listening in class."
		Organizing and transforming	"I made myself a note sheet, the cheat sheet that I need for my exam tomorrow. I went through all my notes and consolidated it and circled and highlighted things that were really important."
		Reviewing records	"…my human factors class is learning laws and learning what works and what doesn't work. That's essentially kind of memorization. You have to see the examples and then know what they are."
		Seeking social assistance	"I'm not afraid to ask the professor because they were in my shoes too."
		Self-evaluating	"For me, I have to write it down because that's how I learned how to take notes and that's how I remember better."
		Structuring environment	"I go to class, whether it's an 8AM or a 4PM class. I'm going to get there. I mean, college isn't cheap so I'm going to go because I'm paying for this. I'll try to be a little pragmatic. Then, I sit down. I try to actively listen. I ask questions."
Blake	3	Keeping records and monitoring	"Transcribing, writing a lot. Any class that I struggle in, which is basically any non-math class or incredibly heavy math class like statics and dynamics which I thought is great … I write it."
		Organizing and transforming	"Look at it as this is maybe something that I see as being kind of esoteric but how can I take this and apply it to other situations because we may actually have an entire field of study related to this."
		Rehearsing and memorizing	"I was studying for an exam and I was going back through. I was transcribing. I read one of the lines out of the book that I could've sworn I read previously but it didn't click. You know, it's like the 3rd or 4th repetition through reading the book and just writing down or just annotating anything else."
		Seeking information	For me, it's important to know where the answer is located or where I might find an answer to any question that might be asked …"

		Seeking social assistance	I'll email teachers a lot and ask them questions…"
		Self-evaluating	"If I do fail, I feel like the easily most important thing for me is just learning why it happened because there may be ways that I can apply, you know … A no gives you almost as much information as a yes in a lot of situations. You can take the same knowledge that you learned from a no and apply it in the future."
Claire	1	Keeping records and monitoring	That's mostly what I do in lectures, just like listen and hear it from their way, write down anything that's important that's not on the slides and make sure that I'm not writing down the extra stuff that's just the fluff, I guess, of the lecture.
		Organizing and transforming	"Sometimes that's not always an option and you need to be able to teach yourself, just pick out what's important from material."
		Rehearsing and memorizing	"To remember a character, I'll just write it down like 20 times, and then you use it a lot in class or in the homework, it focuses on the new characters you're supposed to learn. So it's just repetition, basically."
		Reviewing records	"Do all the homework, because the homework is only going to help you learn it. It's basically a study tool to help you study for when you actually need to recall it."
		Seeking social assistance	"I think always seek help. If not from a professor, but another student, just try and figure out how they're studying and see if you can mimic that."
		Structuring environment	"I feel like the best way to learn at first is through the explanation of your professor… I think just through him lecturing is probably the best way to learn it."
Daisy	2	Keeping records and monitoring	"I go to class and listen to lecture and write it down, and I think it gives me more than some people get from studying and not going to class…"
		Organizing and transforming	"I try to make a sheet…"
		Rehearsing and memorizing	"I like doing the problems, maybe over…"
		Reviewing records	"I want to have the sheet which looks really pretty and nice. You to look over it and understand it, have it written down"
		Seeking information	"…if I try to understand I will Google it and look at interesting sites of it."
		Self-evaluating	"I use [a method] for homework or class or something. It it's something very complex, you should do it, and then, yeah. For me, when I understand something, when I know how and why it works, I know that it works."

Appendix J: The Motivation and Attitudes in Engineering Survey distributed to the introductory IE and introductory MSE courses in sequential explanatory mixed methods study

This appendix provides information for Chapter 4.

Motivation and Attitudes in Engineering Survey

We are interested in your motivation to study engineering and the strategies you use when solving engineering problems. This survey consists of five parts. The first two parts are related to your motivation towards this course. The third and fourth parts are about the strategies that you use to solve engineering problems. The fifth part asks for your demographic information. Please make your best estimate for each item and answer as many questions as possible. There are no right or wrong answers.

This survey requires you to reflect on a course in which you are currently enrolled. Please select the IE course in which you will reflect when answering the items on this survey.

Part I: Students differ in what they want to get out of the courses they take. Use the scale given to rate
how important achieving each of the following is to you in your class, from “Very Unimportant” to “Very
Important”.

		0-Very Unimportant … 6- Very Important
1	Remembering enough from this class to impress my peers.	o o o o o o
2	Doing better than the other students in this class on exams.	o o o o o o
3	Impressing the instructor with my performance.	o o o o o o
4	Proving to my peers that I am a good student.	o o o o o o
5	Doing better than the other students in the class on assignments.	o o o o o o
6	Getting a better grade than other students in this class.	o o o o o o

7	Knowing more than I did previously about these course topics.	o o o o o o
8	Really understanding this course's material.	o o o o o o
9	Feeling satisfied that I got what I wanted from this course.	o o o o o o
10	Getting an A in the class.	o o o o o o
11	Getting a passing grade with as little studying as possible.	o o o o o o
12	Getting through the course with the least amount of time and effort.	o o o o o o
13	Getting through the course with the least amount of time and effort.	o o o o o o
14	Not having to work too hard in this class.	o o o o o o

Part II: The following questions relate to your attitudes and beliefs about your experiences in your course and in your engineering major. Please rate your agreement for each item.

		0- Strong Disagree … **6- Strongly Agree**
15	I will use the information I learn in my engineering course in other classes I will take in the future	o o o o o o o
16	I am confident about my choice of major.	o o o o o o o
17	Engineering is the most rewarding future career I can imagine for myself.	o o o o o o o
18	My interest in an engineering major outweighs any disadvantages I can think of.	o o o o o o o
19	I want to be an engineer.	o o o o o o o
20	I will use the information I learn in this engineering course in the future.	o o o o o o o
21	What I learn in my engineering course will be important for my future occupational success.	o o o o o o o
22	I do not connect my future career with what I am learning in this course.	o o o o o o o
23	My future career determines what is important in this course.	o o o o o o o
24	My future career influences what I learn in this course.	o o o o o o o
25	I expect to do well in this engineering course.	o o o o o o o
26	I am certain I can master the skills being taught in this engineering course.	o o o o o o o
27	I will not use what I learn in this engineering course.	o o o o o o o
28	I believe I will receive an excellent grade in this engineering course.	o o o o o o o

29	I am confident I can do an excellent job on the assignments in this engineering course.	0 0 0 0 0 0 0
30	Considering the difficulty of this engineering course, the teacher, and my skills, I think I will do well in this engineering course.	0 0 0 0 0 0 0
31	Immediate pleasure is more important than what might happen in the future.	0 0 0 0 0 0 0
32	It is better to be considered a success at the end of one's life than to be considered a success today.	0 0 0 0 0 0 0
33	The most important thing in life is how one feels in the long run.	0 0 0 0 0 0 0
34	It is more important to save for the future than to buy what one wants today.	0 0 0 0 0 0 0
35	Long range goals are more important than short range goals.	0 0 0 0 0 0 0
36	What happens in the long run is more important than how one feels right now.	0 0 0 0 0 0 0
37	I don't think much about the future.	0 0 0 0 0 0 0
38	I have been thinking a lot about what I am going to do in the future.	0 0 0 0 0 0 0
39	What will happen in the future is an important consideration in deciding what action to take now.	0 0 0 0 0 0 0
40	I don't like to plan for the future.	0 0 0 0 0 0 0

Part II ctd: The following questions relate to your attitudes and beliefs about your experiences in this
course and in your engineering major. Please rate your agreement for each item.

		0- Strong Disagree … 6- Strongly Agree
41	It's not really important to have future goals for where one wants to be in five or ten years	0 0 0 0 0 0 0
42	One shouldn't think too much about the future.	0 0 0 0 0 0 0
43	It is important to have goals for where one wants to be in five or ten years.	0 0 0 0 0 0 0
44	Planning for the future is a waste of time.	0 0 0 0 0 0 0
45	It is important to have goals for where one wants to be in five or ten years.	0 0 0 0 0 0 0
46	One should be taking steps today to help realize future goals.	0 0 0 0 0 0 0
47	What might happen in the long run should not be a big consideration in making decisions now.	0 0 0 0 0 0 0

Part III: Students use many techniques when solving engineering problems. For the following items, please rate your agreement for each item on a scale from “Strongly Disagree” to “Strongly Agree”

When solving an engineering problem in your course...

		0- Strong Disagree … 6- Strongly Agree
48	I make a plan before solving the problem.	o o o o o o o
49	I know what kind of information in the problem statement is most important.	o o o o o o o
50	I ask myself how reasonable my answer is once I have finished solving a problem.	o o o o o o o
51	I know when each plan I use will be most effective.	o o o o o o o
52	I find myself pausing regularly to check my progress in solving a problem.	o o o o o o o
53	I ask myself as I solve the problem if I am meeting my goal.	o o o o o o o
54	I think I am good at identifying relevant information presented in the problem statement.	o o o o o o o
55	I consider several ways to solve the problem before I answer.	o o o o o o o
56	I summarize what I have learned after solving the problem.	o o o o o o o
57	I ask myself if I have considered all options after I solve the problem.	o o o o o o o
58	I am aware of the plans I use when solving the problem.	o o o o o o o
59	I ask myself whether I have considered my process carefully before I make a choice.	o o o o o o o
60	I use different plans to solve the problem depending on the situation.	o o o o o o o
61	I find myself using helpful methods naturally when I solve the problem.	o o o o o o o
62	After I have solved a problem, I ask myself whether there is a more efficient way to solve it.	o o o o o o o

Part IV: The following questions relate to your attitudes and beliefs about solving typical problems in this course. Please rate how certain you are that you can do each of the things below when solving a problem your course by writing the appropriate number from 0 to 100 in the "Confidence" column.

0	10	20	30	40	50	60	70	80	90	100
Cannot do at all					Moderately can do					Highly certain can do

		Confidence (0-100)
63	Rewrite or summarize the problem statement in my own words.	________
64	Identify the variable(s) to solve for in the problem.	________

65	Identify constraints, or limits, as given in the problem or by my instructor.	________
66	State all assumptions needed to solve the problem.	________
67	Draw a visual representation of the information given in the problem.	________
68	Write out correct equation(s) needed to solve the problem in terms of variables (i.e. without numbers inserted).	________
69	Assign values to variable(s) using information given in the problem.	________
70	Write out numerical value of conversion factors needed to complete calculations.	________
71	Convert all values to the same unit system as needed to complete calculations.	________
72	Perform mathematical operation(s) and/or algebraic activity needed to solve the problem.	________
73	Plug the numerical answer back into equation(s) to check for errors.	________
74	Check that my answer makes sense within the parameters of the problem.	________
75	Check that my answer actually addresses the problem statement.	________
76	Check that my answer has units that match those asked for in the problem statement.	________
77	Identify my final answer by boxing, underlining or circling it.	________
78	Describe in my own words why my answer is correct.	________
79	Describe in my own words why I selected the approach that I did for solving the problem.	________

Part V: Demographic Questions

80. How many credit hours are you enrolled in this semester? _______________

81. What is your gender? O Female O Male

82. With which racial group(s) do you identify? *(Mark ALL that apply)*
O African-American or Black O Caucasian or White
O South Asian (e.g. Indian, Pakistani, Bangladeshi, Sri Lankan, etc.) O Other Asian
O East Asian (e.g. Chinese, Korean, Japanese, etc.) O Native Hawaiian or Pacific Islander
O American Indian or Alaskan Native O Other_____________________________

83. Please indicate if you are of Hispanic origin: O Yes O No

84. Clemson Username (the one you use with @clemson.edu): ___________________________________

85. CU ID Number (X ID: e.g. C12345678): ___________________________________

86. Please indicate if you are: O under 18 years old O 18 years old or over

Appendix K: Original items and intended constructs for FTP and Expectancy Section 2 in MAE survey in IE and MSE courses

This appendix provides information for Chapter 4.

FTP and Expectancy Items from Section 2 of the MAE, with items 14 through 46 described including item number, factor label, and item.

Factor	Type	Item
E	Context-specific	I expect to do well in this engineering course.
E	Context-specific	I am certain I can master the skills being taught in this engineering course.
E	Context-specific	I believe I will receive an excellent grade in this engineering course.
E	Context-specific	I am confident I can do an excellent job on the assignments in this engineering course.
E	Context-specific	Considering the difficulty of this engineering course, the teacher, and my skills, I think I will do well in this engineering course.
F	Domain-specific	I am confident about my choice of major.
F	Domain-specific	Engineering is the most rewarding future career I can imagine for myself.
F	Domain-specific	My interest in an engineering major outweighs any disadvantages I can think of.
F	Domain-specific	I want to be an engineer.
FoP	Context-specific	I do not connect my future career with what I am learning in this course.
FoP	Context-specific	My future career determines what is important in this course.
FoP	Context-specific	My future career influences what I learn in this course.
PI	Context-specific	I will use the information I learn in my engineering course in other classes I will take in the future
PI	Context-specific	I will use the information I learn in this engineering course in the future.
PI	Context-specific	What I learn in my engineering course will be important for my future occupational success.
PI	Context-specific	I will not use what I learn in this engineering course.
V	Domain-general	Immediate pleasure is more important than what might happen in the future.
V	Domain-general	It is better to be considered a success at the end of one's life than to be considered a success today.
V	Domain-general	The most important thing in life is how one feels in the long run.
V	Domain-general	It is more important to save for the future than to buy what one wants today.

V	Domain-general	Long range goals are more important than short range goals.
V	Domain-general	What happens in the long run is more important than how one feels right now.
C	Domain-general	I don't think much about the future.
C	Domain-general	I have been thinking a lot about what I am going to do in the future.
C	Domain-general	What will happen in the future is an important consideration in deciding what action to take now.
C	Domain-general	I don't like to plan for the future.
C	Domain-general	It's not really important to have future goals for where one wants to be in five or ten years
C	Domain-general	One shouldn't think too much about the future.
C	Domain-general	Planning for the future is a waste of time.
C	Domain-general	It is important to have goals for where one wants to be in five or ten years.
C	Domain-general	One should be taking steps today to help realize future goals.
C	Domain-general	What might happen in the long run should not be a big consideration in making decisions now.

Appendix L: Comparison of IE students who were in IE and MSE courses to the remaining IE group

This appendix provides information for Chapter 4. The table below shoes the Fisher's Exact Test for students enrolled in both the IE course and MSE course (N= 8) versus students only enrolled in IE course (N= 139).

X	Table Probability (P)	Two-sided Prob ≤ P	P adjusted using Bonferroni correction
PI14	0.000282947	0.0246	0.7872
F15	0.024631524	0.8907	28.5024
F16	0.007010272	0.6462	20.6784
F17	0.001442679	0.2007	6.4224
F18	0.006061902	0.4479	14.3328
PI19	0.000704738	0.0898	2.8736
PI20	0.015873525	0.8229	26.3328
PI21	0.000110655	0.0456	1.4592
FoP22	0.001940853	0.5821	18.6272
FoP23	0.00012141	0.0496	1.5872
E24	0.001009798	0.0485	1.552
E25	0.002794669	0.1937	6.1984
PI26	0.000227792	0.0705	2.256
E27	0.000563246	0.0745	2.384
E28	0.000274714	0.0323	1.0336
E29	0.000309452	0.0646	2.0672
V30	1.04305E-05	0.0024	0.0768
V31	0.000360699	0.125	4
V32	0.000566831	0.1909	6.1088
V33	0.006127205	0.5268	16.8576
V34	0.001210762	0.2921	9.3472
V35	0.000131229	0.041	1.312
C36	0.000381588	0.0763	2.4416
C37	0.00582242	0.56	17.92
C38	0.011618971	0.5471	17.5072
C39	0.000910982	0.2752	8.8064
C40	3.88E-06	0.0006	0.0192
C41	0.000221998	0.056	1.792
C42	0.000989494	0.124	3.968
C43	1.58063E-05	0.003	0.096
C45	0.019671446	0.6373	20.3936
C46	1.25173E-05	0.0032	0.1024

Appendix M: Comparison (JMP output) for Pearson Chi-squared test with Bonferroni Adjustment for FTP items in MAE survey for MSE and IE samples in sequential explanatory mixed methods study

This appendix provides information for Chapter 4. The Table below shoes the comparison of IE (N=139) and MSE (N=97) using Pearson's Chi-squared test and Bonferroni Adjustment.

X	ChiSquare	P>ChiSq	P adjusted with Bonferroni Correction
PI14	6.729	0.3466	10.7446
F15	8.297	0.1406	4.3586
F16	7.221	0.3009	9.3279
F17	3.902	0.69	21.39
F18	2.583	0.8591	26.6321
PI19	4.164	0.526	16.306
PI20	4.56	0.6013	18.6403
FoP21	6.413	0.3785	11.7335
FoP22	1.804	0.9368	29.0408
FoP23	8.773	0.1867	5.7877
E24	10.472	0.0332	1.0292
E25	17.136	0.0018	0.0558
PI26	6.194	0.4018	12.4558
E27	14.005	0.0156	0.4836
E28	17.796	0.0032	0.0992
E29	16.715	0.0104	0.3224
V30	1.866	0.9316	28.8796
V31	3.592	0.7317	22.6827
V32	4.225	0.6463	20.0353
V33	2.687	0.847	26.257
V34	12.805	0.0462	1.4322
V35	7.013	0.3197	9.9107
C36	2.497	0.8688	26.9328
C37	4.716	0.5807	18.0017
C38	4.782	0.443	13.733
C39	12.153	0.0586	1.8166
C41	1.835	0.9342	28.9602
C42	2.496	0.7771	24.0901
C43	6.142	0.4075	12.6325
C45	8.285	0.0817	2.5327
C46	9.629	0.1412	4.3772

Appendix N: FTP and Expectancy Items from Section 2 of the MAE survey, with items 14 through 46 described including item and factor label.

Factor	Item
PI	I will use the information I learn in my engineering course in other classes I will take in the future.
F	I am confident about my choice of major.
F	Engineering is the most rewarding future career I can imagine for myself.
F	My interest in an engineering major outweighs any disadvantages I can think of.
F	I want to be an engineer.
PI	I will use the information I learn in this engineering course in the future.
PI	What I learn in my engineering course will be important for my future occupational success.
FoP	I do not connect my future career with what I am learning in this course.
FoP	My future career determines what is important in this course.
FoP	My future career influences what I learn in this course.
E	I expect to do well in this engineering course.
E	I am certain I can master the skills being taught in this engineering course.
PI	I will not use what I learn in this engineering course.
E	I believe I will receive an excellent grade in this engineering course.
E	I am confident I can do an excellent job on the assignments in this engineering course.
E	Considering the difficulty of this engineering course, the teacher, and my skills, I think I will do well in this engineering course.
V	Immediate pleasure is more important than what might happen in the future.
V	It is better to be considered a success at the end of one's life than to be considered a success today.
V	The most important thing in life is how one feels in the long run.
V	It is more important to save for the future than to buy what one wants today.
V	Long range goals are more important than short range goals.
V	What happens in the long run is more important than how one feels right now.
C	I don't think much about the future.
C	I have been thinking a lot about what I am going to do in the future.
C	What will happen in the future is an important consideration in deciding what action to take now.
C	I don't like to plan for the future.
C	It's not really important to have future goals for where one wants to be in five or ten years
C	One shouldn't think too much about the future.
C	Planning for the future is a waste of time.

C	It is important to have goals for where one wants to be in five or ten years.
C	One should be taking steps today to help realize future goals.
C	What might happen in the long run should not be a big consideration in making decisions now.

Appendix O: Learning center workshop attendance for engineering versus non-engineering freshmen in the fall before data collection in the MSE course.

At the university, extra credit is available for certain freshman engineering courses; however, workshops are only a part of the requirements (other activities are needed). The details of the bonus activities are listed on the course website on a semester-by-semester basis. Similar skills to the SRL intervention may be found in the learning center workshop series. The chart below depicts the number and percentage of engineering versus non-engineering freshmen who attended workshops through the learning center. The majority of the students registered in the MSE course were freshmen during the fall specified.

Major	**# of Students**	**# attended workshops**	**% attended workshops**
GEN ENG	1,210	416	34.4%
All Other Majors	2,259	151	6.7%
Total	**3,469**	**567**	**16.3%**

*Includes fall faculty and peer-led workshops
**Only full-time, new freshmen in the fall term are included

Appendix P: Learning center workshop attendance for engineering versus non-engineering undergraduates during the fall of the MSE data collection.

Major	# of students	# attended workshop	% attended workshop
GEN ENG	1,817	522	28.7%
All Other Majors	15,811	359	2.3%
Total	**17,628**	**881**	**5.0%**

*Includes fall faculty and peer-led workshops

**All full-time undergraduate students enrolled in the fall term are included

**21 workshops were attended by 18 others (part-time, graduate, or bridge students, or employees). Fall totals are 899 unique WS participants and 1,779 workshops.

Appendix Q: Case Studies Interview 2 on Goal Setting

Section 1: Connecting Goals to FTP

Remind me, what are your goals for the future?

What are your personal goals for the future?
What are your career goals for the future?
Describe where you see yourself in 10 years?

Can you think of anything that would make you change your goals?

Are there other goals you have considered?

Ask written follow-up questions from first interview and any other analysis.

Section 2: Connecting Goals to SRL

How do you set goals?

When do you set goals?

Does this differ depending on the type of goal you are setting?

Describe a goal you have in your major.
Why did you set this goal?
How do you go about achieving this goal?
Do you have other goals in your major?
How do you go about achieving this goal(s)?

Describe a goal you have for your current courses.

Why did you set this goal?
How do you go about achieving this goal?
Do you have other goals for your courses?
How do you go about achieving this goal(s)?

Describe a goal you have for studying/when you study.

Why did you set this goal?
How do you go about achieving this goal?
Do you have other goals for studying?
How do you go about achieving this goal(s)?

Do you believe it is important to set goals?

For your coursework?
Why or why not?
For your major?
Why or why not?
For your career?
Why or why not?
For studying?
Why or why not?

Section 3: Creating a Path of Distal Future Goal and Proximal Sub-goals

Explain the definition of a step. Explain the definition of a path.

Directions: I have a set of cards, which represent steps, which list goals you mentioned in your first interview. We will eventually create a picture of your goals with these cards.

Put the cards on the table.

Are there any goals you would like to add?

What are they?
Why?

Are there any goals you would like to delete?

Which ones?
Why?

Are there goals you would like to edit?
What is your most important future goal in this set?

In the distant future?
What is the future goal that most influenced the adoption of this set of goals?

<u>Directions</u>: Based on this goal as the end of a path of goals, please create a path leading up to this goal. Feel free to create extra cards.

Take a picture of the path.

<u>Section 4: Path characteristics</u>

Are there any you goals you would like to edit?

Are there any you would like to add now?
Are there any you would like to change?

What is the most important goal in the path? You may describe multiple goals for different reasons.

What are you doing now to meet this goal?

Where in this path is 10 years from now?

1? 5?
Tell me a little about the timing of this path.

Why have you set each of these goals?

Ask the student if they would like to write on the cards themselves or you can write the answers they give you for the following questions. Walk through each step in the path.

What strategies do you feel you need to utilize to meet each of these goals?
How long will each step on this path take?
Please write on each card what strategies you must utilize to obtain the goal successfully.
Define success.

Define failure.
Are there other paths you've considered? (3)
Why?
Which goal do you most want to reach? (4)
Which goal, if you obtained it, would make you feel most successful?
Why?
Is there a way you could alter or rearrange your path to make it easier? (5)
Why did you not choose this path?
Are there goals you could skip and still obtain your future goal? (6)
Could you change the path and still obtain your future goal? (6)
Is your final step fixed? Do you plan on changing your final step? (8)
Are there any you goals you would like to edit?

Take a picture of the path if it has been updated.

<u>Section 5: Contingent Versus Non-Contingent Paths</u>
Do any of these goals in your path rely on the success of another?
Why?
Are any of these goals a prerequisite of another goal?
Why?

<u>Section 6: After the interview</u>
After the interview, please write on each card the following:

1. how long the participant said it would take to reach each step
2. how important the step is from 1-10 in completing the path
3. what strategies the student would use to reach each step/goal
4. how would the participant define success when meeting each step/goal?

Appendix R: Cody's list of goals from his path, including the type of goal, or grouping, and the strategies used to achieve each goal

Type of Goal	Goal	Strategies Used or Notes
Core Goals	Be happy	• Reach out/ Social responsibility or environmental responsibility • Pursue/create change, but not just for the sake of change • Be active (socially and physically) • Pursue knowledge, always • Pursue leadership • Continue to look for ways to improve self Note: DFG I
	Pursue/create change, but not just for the sake of change	Note: also labeled in "Constant Goals"
	Make a difference	• Reach out/ Social responsibility or environmental responsibility • Pursue/create change, but not just for the sake of change • Be active (socially and physically) • Pursue knowledge, always • Pursue leadership • Continue to look for ways to improve self Note: DFG II
	Pursue leadership	Note: also labeled "Constant Goals"
	Pursue knowledge, always	Note: also labeled "Constant Goals"
	Continue to look for ways to improve self	Note: also labeled "Constant Goals"
	Live more sustainably	• Reach out/ Social responsibility or environmental responsibility • Pursue/create change, but not just for the sake of "change • Be active (socially and physically) • Pursue knowledge, always • Pursue leadership • Continue to look for ways to improve self Note: DFG III
	Reach out/ Social responsibility or environmental responsibility	Note: also labeled "Constant Goals"

Professional Goals	Be a leader in profession	• Take on extra tasks • Perform well at job • Connect with management/ admins • Be active within job community
	Consult in humanitarian projects	• Finish relief work project • Make global connections • Traveling • Gain professional experience
	Be on the creative board	• Perform well • Present good ideas • Reach out to current members • Think on your own
Specific Goals	Gain work experience in aerospace	• Get internship • Perform well [at internship] • GPA up • Networking • Projects @ school
	[Gain] work experience at an energy company	• Networking • Keep GPA up • [Be involved in] extracurriculars
	[Gain] work experience in "Renewable energy"	• Get internship • Perform well [at internship] • Network/making connections • Keep GPA up
	Progress the renewable energy field	• Do research undergrad • Do research on own • Speak up/ make your voice heard
	[Intern at an energy company] ([next summer])	• Networking • Passing drug test • Performing well at internship
	[Obtain a] possible internship	Removed
	Intern with [one of two energy companies in an RE position]	• Keeping up GPA • Networking • Career fair
	[Gain] work experience in nuclear energy	• Get internship • Perform well [in internship]
School Goals	Graduate with no/minimal debt	• Pass classes 1st try • Apply departmental scholarships • Work while at school
	Do classes in energy-related curriculum	• Scheduling

	Join another [Undergraduate Research Team/Course] or do undergraduate research/[Undergraduate professional] internship	• Scheduling • Talking to teachers
	Attend graduate school if an offer	• Keep GPA up • Do research on schools and companies that will pay
Family or Social Goals	Create memories before settling down	• Try everything twice • Don't be afraid to be spontaneous • Keep bail money at hand
	Be active (socially and physically)	Note: also labeled "Constant Goals"
	Hike the [US trail]	• Research • Be fit • Find a group to go with
	Hike the [US trail]	• Do research • Be fit • Get permits • And time off
	Get a dog (also "Get a new best friend")	• Continue volunteering at animal shelters • Look online • Do research
	Start a family	• Be a cool guy • Wear more sunglasses • Work out more • Be ready to compromise • Be social
Personal Goals	Live in Charleston (or by some body of water)	• Research and go
	Move out west (because [where he lives] is hot)	• Research cities/areas • Go and visit
	Be successful (as a whole, primarily relationships)	• Reach out/ Social responsibility or environmental responsibility • Pursue/create change, but not just for the sake of change • Be active (socially and physically) • Pursue knowledge, always • Pursue leadership • Continue to look for ways to improve self Note: DFG IV

Humanitarian Goals	Set up relief project through [university]	• Making connections email/ student • Acting on connections
	Work on relief work for developing country project	• Acting on connections • Research (land surveys) • Physical movement
NA	Travel	• Find a pretty place • Go there • Work for $
	Take time off	• Just go for it

Appendix S: Updated FTP codebook including new code names through the sequential explanatory mixed methods study

Category	**Code Name**	**Description**	**Example Quotes**
Future	Divergent Path	The student describes a split in their goals in the future (or past), often depicted by multiple branches in an FTP path.	"I think pretty much all of undergrad is the same. Maybe I decide I want to go into bioengineering or go to med school, another medically related thing, like med school or PA school." -Barb
Future	Convergent Path	The student describes a split in their goals in the future (or past) in which the goals eventually converge to a single goal, often depicted as split branches intersect at a single goal in an FTP path.	"Anything from that, to actually being in design, being on the floor, working on spaceships, working on turbine engines for airplanes, stuff like that. Pretty much anything that could be more directly related to aircraft." -Cody
Future	Contingent Path	When the student describes a future success as "dependent on more immediate success"[149].	"Then residency rely on me getting into pharmacy school and completing that." -Barb
Future	Non Contingent Path	When the student describes an 'immediate success or failure' which s/he perceives to be non-consequential in the opportunity to engage in a future goal"[149].	"I don't think not going to graduate school would really hurt my feelings that much." -Greg
Future	Distal Future Goal	When the student describes the most important or influential goal in their proposed future.	"This is kind of endgame, so this is where all of this will amount to: being happy, making a difference, being successful." -Cody
Future to Past/Present Connection	Connectedness	The student describes how what they do in the present or what they have is connected to what they will do in the future or what their future goals are.	"I think [getting research experience is] important; if I still hadn't narrowed my interest in MSE, research experience would help make sure that I'm in a field that interests me." -Greg

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